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Roentgenologic and Pathologic Aspects of Pulmonary Tumors Probably Alveolar in Origin

With Report of Six Cases, One of Them Complicated by Torulosis of the Central Nervous System[1]

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AMONG PRIMARY tumors of the chest, pulmonary alveolar-cell tumors are believed to be of relatively rare occurrence. They are characterized by their apparent independence of the bronchial system and by evidence of circumscribed or diffuse intra-alveolar origin and growth. In a recent review of lung tumors, Shinall (5) mentions that, during a five-year period, he did not see a single definite instance of carcinoma arising from the pulmonary alveoli. While the comparative scarcity of this type of tumor is not questioned, its infrequent observation may be due, at least in part, to the intrinsic difficulties of premortem radiologic and clinical diagnosis. The purpose of this report is to present six probable cases of alveolar-cell tumor and to discuss their differentiation from bronchiogenic and metastatic lung tumors and from infections with a similar x-ray appearance.

CASE 1: G. D., a 49-year-old baker, was first seen on May 10, 1940, complaining of cough, pain in the chest, and loss of weight for the past five months. Previous and family histories were not significant. The physical examination showed the patient to be cyanotic, dyspneic, and emaciated. Resonance was impaired over the bases of both lungs, especially on the left, where the breath sounds were diminished. The roentgenogram showed a large pleural effusion on the left and small scattered radiopacities in the right lung, suggestive of metastatic tumor invasion. (Due to the death of the roentgenologist, the roentgenograms are no longer available.) Bronchoscopy failed to show any obstruction. The symptoms increased in severity and, according to the roentgenologic report, pathologic changes became more visible in the left chest. Death occurred Sept. 5, 1940.

Autopsy: The left pleural cavity contained 800 c.c., the right 100 c.c., of yellow fluid. Both lungs were studded with firm gray nodules, measuring about 0.3 cm. in diameter and occasionally coalescing. Bronchi and bronchioles were free from tumor. Liver and adrenals showed nodules similar to those in the lungs.

Microscopic Examination: The nodules were composed of anaplastic columnar cells that lined fairly well preserved alveolar walls. The cells often formed papillary projections; some cells contained dust particles or pigment. Mitosis was infrequent. Occasional bronchi revealed nests of tumor cells in the submucosa. Thrombosis, inflammation, and early abscess formation were seen in one section. Metastases, mostly in a glandular pattern, were found in the hilar lymph nodes, liver, and adrenals.

CASE 2: L. C., a 53-year-old woman, entered the hospital on June 24, 1943, complaining of blurred vision, difficulty in articulation, drowsiness, and loss of weight. Her mother had died at sixty-five of a brain tumor. The past personal history was noncontributory.

The patient was emaciated, with lungs normal to percussion and auscultation. She showed frequent causeless laughter and giggling, a positive Romberg sign, mild ataxia in gait, bilateral nys-

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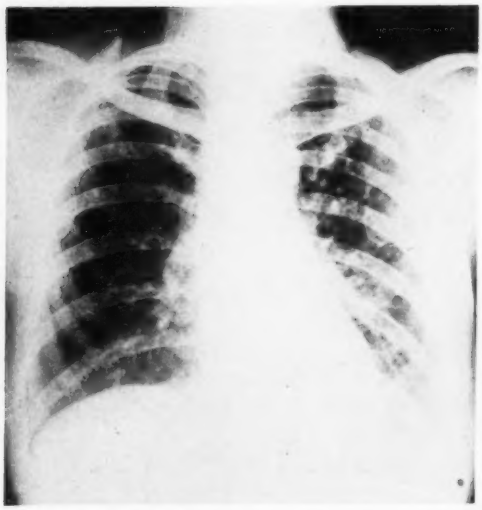


Fig. 1. Case 2. Multiple small areas of increased density throughout the upper three-fourths of both lung fields.

tagmus, and slight stiffness of the neck. The spinal fluid findings were as follows: cells 181, globulin trace, protein 130 mg., sugar 41.5 mg. per 100 c.c. In the cisternal fluid, budding, doubly refractive yeast-like cells were found. *Cryptococci hominis* (Torula organisms) were isolated from an inoculated mouse and a guinea-pig.

Roentgen examination of the chest (reported by Dr. J. H. Jamison, Denver) disclosed multiple small areas of increased density distributed throughout the upper three-fourths of both lung fields (Fig. 1). These areas did not have the characteristics of pulmonary tuberculosis but corresponded more closely to the findings in a fungous infection such as moniliasis, aspergillosis, or blastomycosis. The cardiac silhouette was within normal limits as to size and shape, and there was no irregularity of either hemidiaphragm.

Diagnosis of torulosis was made and the patient was treated with sulfadiazine. The clinical course was slowly retrogressive; signs of meningitis became more pronounced. Iodides and acriflavin hydrochloride were administered. Torula organisms were found in six out of eight specimens of spinal fluid. Death occurred on Sept. 22, 1943, three months after admission.

Autopsy: The left pleural cavity contained 300 c.c. of straw-colored fluid; the right was dry. In both lungs were numerous firm, gray, round tumor foci, measuring 0.5 to 1.0 cm. in diameter and occasionally encroaching upon the pleura. Bronchi and mediastinal lymph nodes were not affected. The leptomeninges showed scattered areas of thickening without definite exudate. Globular tumor foci, similar to those in the lungs, were scattered through the brain; some showed central softening.

Microscopic Examination (Fig. 2): In the tumor foci, the alveolar walls were thickened and lined by cuboidal, epithelial-like neoplastic cells. Mitoses, giant cells, fragmented nuclei, papillary projections, and desquamation of tumor cells into the alveolar lumina were observed. Some alveoli contained polymorphonuclears and macrophages. Occasional lymphatics contained tumor cells. Bronchi and lymph nodes were not affected. The neoplastic foci in the brain displayed a papillary-glandular pattern

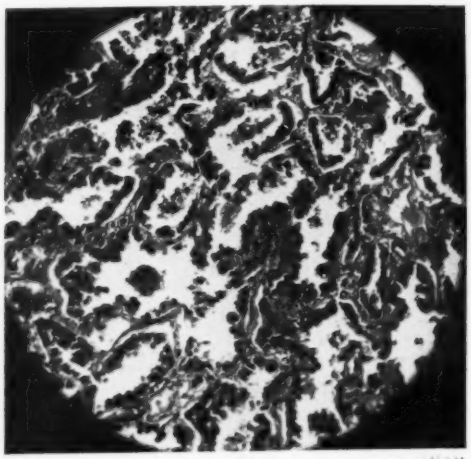


Fig. 2. Case 2. Photomicrograph showing preservation of alveolar framework; alveoli lined and filled with epithelial-like cells. × 45.

and, in many places, showed central necrosis. The thickened areas in the meninges also were composed of neoplastic cells. No *Cryptococci* could be demonstrated and torula meningitis was not apparent.

CASE 3: E. R., a 17-year-old school girl, had a hacking productive cough, accompanied by loss of weight and strength, in July 1942. In December, she suffered from pneumonia for three weeks. Symptoms continued, and sputum was occasionally blood-streaked. A pleurisy with effusion developed in March 1943. Physical examination, on July 1, 1943, revealed a tall, thin girl with a loose, rattling cough. The chest was retracted on the left, with dullness, coarse moist râles, and bronchial breath sounds. There were also scattered râles in the central field on the right.

Roentgen examination (by Dr. Van Atta, Albuquerque, N. M.) showed extensive nodular infiltrative changes (Fig. 3), partly confluent, in the right middle and lower thirds (costophrenic angle excepted). A slight tenting of the right diaphragm indicated pleural adhesions. The left hemithorax was almost homogeneously dense. Though the cardiac outline could not be definitely ascertained, the heart and the trachea seemed to be markedly displaced to the left. Judged by the position of the

Magenblase, the left diaphragm appeared elevated. These criteria rather pointed to extensive atelectatic and fibrotic changes or tumor formation than to pleural effusion, but complication by pleural fluid was considered plausible roentgenologically.

The sputum (smears and culture) was persistently negative for tubercle bacilli or fungi. A diagnosis of pulmonary cancer was made. The course was rapidly retrogressive, with increasing dyspnea. Death occurred Aug. 29, 1943.

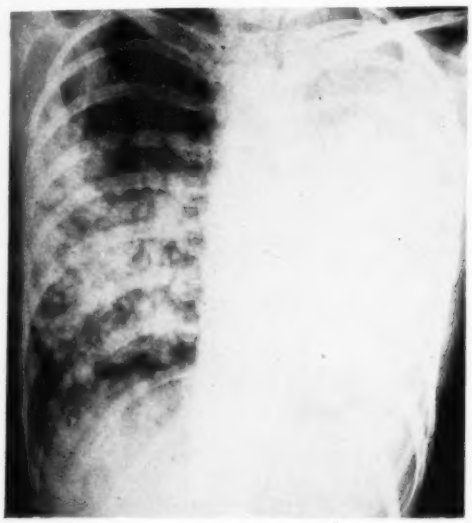


Fig. 3. Case 3. Extensive nodular infiltration in right middle and lower thirds. Almost complete radiopacity over left hemithorax with elevation of left diaphragm and displacement of heart and trachea to the left.

Autopsy: The left pleural cavity was obliterated. The left lung and right middle and lower lobes were occupied by grayish, firm, nodular tumor, with sclerosis of the intervening tissue. Nodules varied from the size of a pinhead to 1.0 cm. in diameter. The bronchi showed no involvement. There were no metastases.

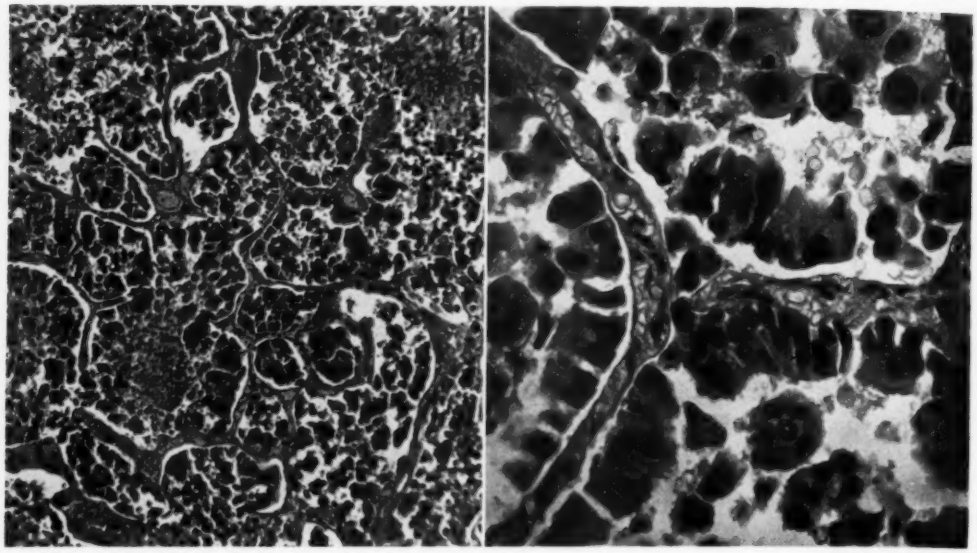
Microscopic Examination: Alveolar walls were partially or completely lined by columnar cells with eosinophilic, granular, or vacuolated cytoplasm and oval or irregular nuclei. Mitosis was rare. Pseudostratification, papillary protrusions, and mucinous secretion were not infrequent. Some fields showed necrosis and infiltration with macrophages and leukocytes. There was marked fibrosis of the intervening lung tissue. Bronchioles and lymph nodes were free from tumor.

CASE 4:[2] F. M., a 76-year-old man, was admitted on Jan. 16, 1941, complaining of progressive shortness of breath for one year, and of increasing dyspnea, cough, and swelling of the feet during recent days. Neither the past nor the family history was remarkable. Physical examination revealed extreme dyspnea, orthopnea, and cyanosis; the chest was barrel-shaped; moist râles were heard in the base of each lung, combined with bilateral bronchial breathing.

Fig. 4. Case 4. Extensive infiltrative-consolidative changes in left middle and lower thirds. Prominence of bronchial markings in right infraclavicular region and lower third. Some "honeycombing" in some areas. Slight displacement of heart to the left. Small amount of pleural effusion, left.

X-ray examination of the chest (Colorado General Hospital, Jan. 16, 1941) revealed extensive infiltrative-consolidative changes in the left middle and lower thirds (Fig. 4) and marked fibrosis in the right infraclavicular region and lower lobe. There was a suspicion of "honeycombing" in the right lower lobe and in the more translucent areas of the left chest. The outlines of the left heart border and the left diaphragm could not be definitely ascertained, but to judge from the position of the right cardiac border, there seemed to be some displacement of the heart to the left. Homogeneous density in the left costophrenic angle and lateral lower third suggested pleural effusion. The differential x-ray diagnosis rested between (1) pneumonitis with bronchiectasis (diagnosis of choice), (2) widespread chronic tuberculosis with fibrosis and bronchiectasis, (3) tumor invasion of the left hilus and lower lobe with inflammatory complications and bronchiectasis. (X-ray check examination was advised for a more definite diagnosis, but the patient grew rapidly worse and died before further studies could be attempted.)

[2] This case was included in the review on "The Morphology of Primary Carcinoma of the Human Lung" by R. M. Mulligan and F. R. Harper, J. Thoracic Surg. **12**: 734–752, 1943.



Figs. 5 and 6. Case 4. Photomicrographs showing preservation of alveolar framework; alveoli lined and filled with neoplastic cells. × 45 and × 400.

The sputum was positive for type III pneumococci, and a diagnosis of pneumonia was made. The patient was placed in an oxygen tent and given antipneumococcus serum and glucose solution intravenously. The course, however, was steadily downhill, and death occurred Jan. 25, 1941.

Autopsy: Scattered adhesions in the left pleural cavity were present. The right lung (630 gm.) was congested and subcrepitant in its posterior portion. The left lung (1,210 gm.) showed a mixed grayish yellow and white firm tumor (measuring 10 × 10 × 14 cm.), occupying the anterolateral portion of the upper lobe, with some satellite nodules in the vicinity. The lower lobe was congested and free from tumor. Metastases were found in regional and peripancreatic lymph nodes, pancreas, adrenals, and kidneys

Microscopic Examination (Figs. 5 and 6): In the left upper lobe highly anaplastic cells filled and, in many fields, clearly lined the alveoli. Many mitoses were noted. There were masses of tumor cells in vessels and lymphatics. In some fields, alveolar walls were broken down, but generally they were intact. Scattered areas of necrosis occurred. Bronchi and bronchioles revealed no point of origin for the neoplasm. Metastases exhibited anaplastic cells with an atypical glandular pattern.

CASE 5: H. W., a 58-year-old tailor, was admitted to the hospital on April 8, 1944, with a cough of one year's duration, progressive weakness, and considerable loss of weight. He had been in the National Jewish Hospital where a diagnosis of lung tumor was made and immediate surgery was advised. Three weeks before admission, a severe coughing attack occurred, with dyspnea and cyanosis. The patient was placed in an oxygen tent. There was no record of any previous disease, except influenza in 1918. The family history was negative. On admission the patient was in great distress, with dyspnea and cyanosis. The chest examination was difficult, due to continuous coughing. The respiratory excursions were more pronounced on the left. Coarse moist râles were audible everywhere. There was dullness to percussion along both sides of the spine, particularly on the left. The breath sounds decreased over the right field posteriorly.

X-ray examination of the chest (National Jewish Hospital, Denver, Feb. 24, 1944) showed a large oval area of infiltration and consolidation over the left hilus as well as extensive peribronchial infiltrative changes radiating from the left hilus throughout the left lung, most pronounced in the first and second costal interspaces (Fig. 7). The left lung appeared generally less radiotranslucent than the corresponding right. The measurements of the heart reached the upper limits of the normal. The left diaphragm was slightly elevated. The position of the heart and the appearance of the costophrenic angles were normal. The radiological diagnosis was primary malignant tumor invasion of the chest, apparently originating in the region of the left hilus. Exclusion of acute infection by history and clinical examination was suggested.

The patient remained extremely dyspneic, became comatose, and died on the third day after admission.

Autopsy: The lower third of the right pleural cavity was obliterated. The left pleural cavity showed

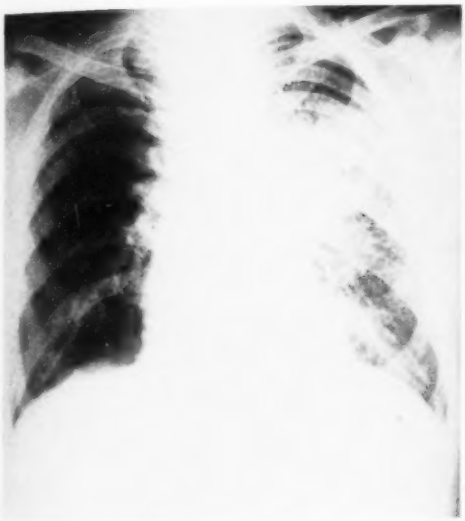


Fig. 7. Case 5. Large oval area of infiltration over upper portion of left hilus. Extensive peribronchial infiltration radiating from left hilus throughout left lung (most prominent in first and second costal interspaces).

studding of the visceral and parietal pleura with small, firm, rounded nodules; 300 c.c. of fluid were present on the right and 1,500 c.c. on the left. The weight of the lungs was 675 gm. (right) and 945 gm. (left). The left upper lobe was firm and non-crepitant, with a contracted area with deep fissuring of the surface on the lateral aspect. A cut section exhibited an almost solid mass of compact, pale gray neoplastic infiltration (Fig. 8). The lower lobe showed a few small tumor nodules. The right lung displayed a firm, uniform, reddish-gray consolidation in the middle lobe, and a few small abscesses in connection with dilated bronchi in the lower lobe. The bronchi were otherwise normal. There were no metastases, with the exception of implants on the pleura and pericardium.

Microscopic Examination (Fig. 9): The left upper lobe showed the alveolar structure preserved in most fields. The alveolar walls as well as those of some alveolar ducts were thickened and lined by cuboidal or cylindrical cells, with occasional mitoses and giant cells. Papillary protrusions and cellular desquamation, sometimes with solid plugs of tumor cells, were observed. Mucoid material, dust cells, and foamy phagocytes were present in some of the neoplastic alveoli. The new growth was broken up in several places by coarse strands of connective tissue. In some fields, the alveolar pattern was less distinct, and the appearance resembled bronchiogenic adenocarcinoma. Bronchi and bronchioles, however, were free from tumor. Many lymphatics contained tumor cells. Pleural foci exhibited neoplastic tissue in a glandular pattern or in small solid

Fig. 8. Case 5. Diffuse neoplastic infiltration of upper lobe; scattered nodules in lower lobe. Note absence of bronchial involvement.

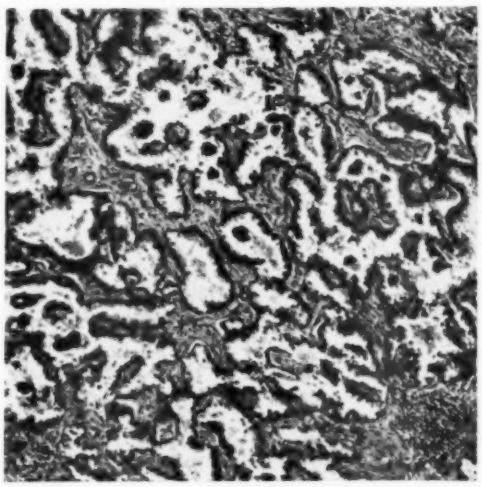


Fig. 9. Case 5. Photomicrograph showing neoplastic alveolar lining similar to that seen in other cases; thickening of alveolar walls; interstitial sclerosis. × 35.

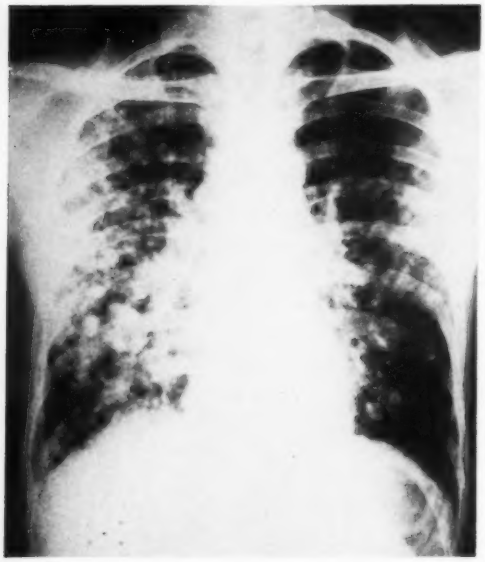


Fig. 10. Case 6. Multiple rounded and oval areas of radiopacity (apparently tumor invasion) throughout both lungs.

nests. The right middle lobe showed widespread organizing pneumonia and a large number of alveoli filled with macrophages.

CASE 6: This case was described from a pathological point of view by one of us (N.) in the *Journal of Thoracic Surgery* (4). Since, however, no roentgenograms of the case were ever published, nor was it ever discussed roentgenologically, a brief résumé with roentgen findings appears to be indicated in this connection.

M. Q., a 39-year-old WPA worker of Mexican descent, who had been a miner from 1918 to 1936, was admitted to the Colorado General Hospital on Nov. 17, 1938. His chief complaints were loss of weight, severe and persistent cough, weakness, and postprandial epigastric distress. The breath sounds were somewhat harsh over both apices. Examinations of the gastro-intestinal and genito-urinary tracts by clinical, laboratory, and x-ray methods were essentially negative.

X-ray studies of the chest, on Nov. 22, 1938 (Fig. 10), showed both lung fields studded with multiple round or oval areas of increased density ranging from the size of a millet seed to that of a cherry, partly confluent and especially prominent in the hili and middle thirds. The heart was of normal size and position. The left costophrenic angle was slightly obtuse. The right costophrenic angle and the diaphragm were normal.

The x-ray appearance primarily suggested far-advanced pulmonary metastases but, considering the patient's history and apical involvement, complications by additional factors (silicosis, fungous disease, or tuberculosis) could not be definitely ruled out.

Further x-ray and clinical examinations (gastro-intestinal and genito-urinary tracts, bones, etc.) failed to reveal any evidence of primary tumor.

More for diagnostic than therapeutic purposes, x-ray deep therapy was administered to the chest in two different series: 2,900 r to the left chest (from Dec. 5 to Dec. 13, 1938) and 1,600 r to the right chest (from Jan. 7 to Jan. 11, 1939).

X-ray examination (Dec. 27, 1938) following deep therapy of the left chest showed some decrease in the extent of the tumor involvement of the left lung. This improvement was only temporary, however, and the second treatment series had to be discontinued on account of untoward symptoms (slight fever, increasing weakness, and vomiting). The patient was discharged to a convalescent home but left for his own home where he died a few weeks later (Feb. 7, 1939).

The anatomical-pathologic diagnosis was: (1) primary multiple alveolar-cell tumor of both lungs; (2) chronic pneumonia in the remaining lung tissue; (3) slight pleural adhesions in the right lung; (4) tumor metastases in mediastinal and periaortic lymph nodes, liver, and kidneys; (5) emaciation.

Figure 11 shows a gross section of the lung. The microscopic findings as well as the pathologic reasoning leading to this unusual diagnosis are discussed in detail in the article cited above.

DISCUSSION

Case 1 seems typical of the multiple nodular type of alveolar-cell tumor. The symptoms were similar to those of bronchiogenic carcinoma, *i.e.*, cough, pain in the chest, loss of weight, weakness, and dyspnea. Bronchoscopy, however, was negative, and necropsy failed to reveal a bronchiogenic origin of the tumor.

Case 2, also, is fairly typical of the multiple nodular type. The symptoms, however, were predominantly due to cerebral and meningeal metastases; there was little clinical evidence of a primary pulmonary tumor. It is believed that this is the first report of clinical torulosis associated with alveolar-cell tumor of the lung. Why the torulosis failed to produce the usual histologic lesions in the brain is undetermined. That the reported presence of *Torula histolytica* was due to clinical or laboratory error seems remote, as the examinations of the spinal fluid were repeated some eight times, and specimens were examined independently by the lab-

oratory of the Presbyterian Hospital and the Department of Bacteriology of the University of Colorado. Both laboratories agreed on the identification of the yeast. Possibly the answer lies in the existence of a Cryptococcus that is pathogenic for white mice but is not productive of pathologic lesions in man.

Case 3, again a nodular type, found in a girl of only seventeen, failed to show metastases and revealed somewhat less cellular anaplasia than the first two cases.

Case 4 is fairly characteristic of the diffuse form. The diagnosis was obscured by an associated bronchopneumonia with type III pneumococci in the sputum. The neoplasm was highly malignant and produced widespread metastases.

Case 5 is probably another good example of the predominantly diffuse form. Distant metastases were absent. Although the structure of the tumor in some areas was suggestive of bronchiogenic adenocarcinoma, no starting point in the bronchial system was found.

Case 6 is a very good instance of the nodular form, leading to widespread metastases.

In a review of this subject in 1942, two of us (Neubuerger and Geever, 3) were able to collect 24 clear-cut cases of alveolar-cell tumor from the world literature. Since the appearance of that review, Dacie and Hoyle (2) and Wood (8) have reported 2 additional cases. Some authors designated these tumors as alveolar carcinoma in the belief that they had their origin in alveolar epithelium. This, however, introduced a controversial histologic subject, as anatomists do not agree on the presence or histogenetic character of the alveolar lining cells. And for this reason we expressed preference for the term "alveolar-cell tumor." Microscopic examination in all cases here presented favored the belief that the origin of the neoplastic growth was in the alveolar walls.

A completely satisfactory proof of this opinion cannot, of course, be offered. Opponents of the existence of the alveolar-

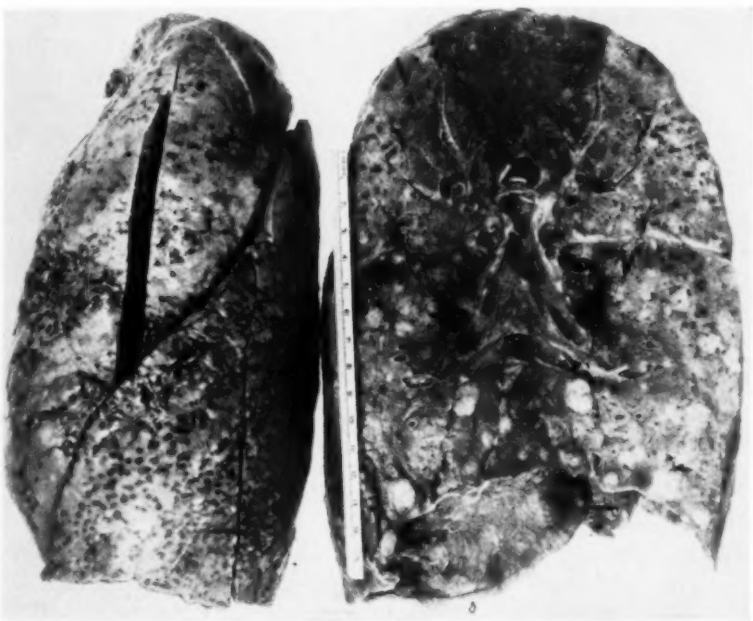


Fig. 11. Case 6. Alveolar-cell tumor with multiple discrete foci.

cell tumor will maintain the conviction that the neoplasms under discussion arise from some single focus, probably in a smaller bronchus, and then metastasize rapidly to other parts of the lungs, by way of downgrowth in the bronchial tree and by extension through the pores of Kohn, the lymphatics, and blood vessels. Only serial sections through the lungs would enable one to make an irrefutable statement as to lack of primary bronchial involvement in a given case. We have discussed these controversial points in the above-cited review. In spite of the unavoidable inadequacies in the argumentation, the cases here reported offer so many differences from other forms of pulmonary tumors that they should be given special consideration.

Although the majority of alveolar-cell tumors have been definitely malignant, some were borderline or histologically benign. The older cases were reviewed in our earlier paper. More recently, Sims (6) has reported a benign tumor of this class in a 42-year-old man and designated it as "bilateral multiple pulmonary adenomatosis." Bell (1) described a similar case and called it "extensive diffuse epithelialization of the alveoli" rather than true neoplasm. Taft and Nickerson (7) saw two similar examples, with marked mucous secretion ("pulmonary mucous epithelial hyperplasia"). Our third case was somewhat similar: the histologic grade of malignancy was slightly lower than in the other instances, mucinous secretion was marked, and regional and distant metastases were absent.

In an analysis of all reported cases, it was found that the clinical features of this tumor are similar to those of other lung tumors, *i.e.*, cough, pain in the chest, pleural effusion, cyanosis, and bloody sputum. In some instances the prevailing symptoms were due to intracranial metastases, as in our own Case 2. Even in the cases with histologically "benign" tumors, the final outcome is often fatal as a result of involvement of large areas of the lung or secondary infectious processes. The prognosis, then, is unfavorable in the overwhelming majority of cases. Unilateral or monolobar tumors of the diffuse type occasionally may be amenable to surgical or x-ray treatment.

From a roentgenologic point of view, the protean appearance of alveolar-cell tumor explains the difficulty of conclusive diagnosis. As demonstrated by our cases, the roentgen appearance may simulate bronchiogenic carcinoma (Case 5) or a metastatic tumor (Cases 1 and 6), or it may have the appearance of fungous or tuberculous infection (Case 2) or of pneumonitis (Cases 3 and 4). As a further confusing factor, complications, especially pleural effusion, bronchiectasis, and cavitation, may enter into the picture, as occurred in Cases 3 and 4. These complications may be the direct result of the tumor, through pressure (atelectasis), invasion of the pleura (effusion), or tissue destruction (cavities), or they may be entirely incidental and have no connection at all with the neoplasm, as, for instance, the torula infection in Case 2 and the pneumococcus pneumonia in Case 4. In 3 of the 6 cases, a pulmonary neoplasm was definitely diagnosed roentgenologically, premortem, though the true character of the alveolar-cell tumor could not be gauged in the roentgenogram: because of the multiple bilateral rounded foci, Cases 1 and 6 were diagnosed as pulmonary metastases, while Case 5 seemed to have all the earmarks of a bronchiogenic carcinoma. In 2 other cases (3 and 4), tumor invasion was more or less seriously considered, but the general picture was too obscured by inflammatory changes and complications to make that the diagnosis of choice.

It is worth while to note that some of the older cases were misdiagnosed as tuberculosis or pneumonia, even following gross necropsy study. Clinical factors may tip the scales in favor of tumor diagnosis, as lack of fever, loss of weight, progressive weakness, a chronic course, etc., but it must be assumed that, at the present stage of our knowledge, as far as alveolar-cell tumor of the lungs is concerned, particularly its diffuse type, the definite

diagnosis in the majority of cases lies beyond the realm of roentgenologic differentiation and can be made only by microscopic examination. However, in all patients with multiple nodular, seemingly metastatic shadows, without evidence of a primary tumor elsewhere, this neoplasm should be considered.

SUMMARY

1. Six cases of apparent pulmonary alveolar-cell tumor are presented. In one patient the diagnosis was obscured by a complicating torulosis.

2. The roentgenologic, pathologic, and clinical aspects of this type of tumor are discussed. The difficulty of roentgenologic and clinical diagnosis is stressed.

3. Although not nearly so common as bronchiogenic neoplasms, tumors may arise in the pulmonary alveoli and produce fairly distinctive pathologic changes.

NOTE: For material and substantial help, the authors are especially indebted to Dr. C. W. Maynard, Pueblo, Col., Dr. C. Mulky and Dr. J. R. Van Atta, Albuquerque, N. M., Dr. J. H. Jamison, Dr. P. Carson, Dr. C. J. Kaufman, and Dr. A. Ravin of Denver, Col., to whom they express their gratitude.

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The Roentgen Features of Eosinophilic Infiltrations in the Lungs[1]

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THE CONDITION to be described has been previously reported under various designations, including eosinophilic pneumonia, Löffler's pneumonia, Löffler's syndrome, and transient pulmonary infiltrates with eosinophilia. Between 1931 and 1936, Löffler reported 51 cases in which transient pulmonary exudates were found associated with eosinophilia. He considered the condition a well defined clinical entity, characterized roentgenographically by the sudden appearance of pulmonary infiltrates of variable size, density, and distribution (1). He classified these shadows in four groups: (1) extensive areas of massive density simulating tuberculous consolidation; (2) smaller round single foci, like those of the early tuberculous infiltrate; (3) multiple small infiltrates in one or both lungs; (4) infiltrates of lobar extent simulating abortive pneumonia. The main characteristic of these infiltrates was their sudden appearance, with complete disappearance within three to eight days.

The other characteristic feature of the condition was the accompanying eosinophilia with counts ranging up to 66 per cent, but averaging 10 to 30 per cent. There appeared to be no correspondence between the degree of eosinophilia and the extent of the pulmonary involvement. The benign character of the associated symptoms was another clinical feature. There was little or no fever, and slight disturbance in the general condition of the patients. The meagerness of abnormal physical findings in the lungs and of pulmonary symptoms was also noteworthy.

All of Löffler's cases were of the benign variety and of very brief duration. Other authors (2, 3, 4, 5) have described more chronic forms of the disease, frequently associated with more severe symptoms. In these the pulmonary infiltrations remained demonstrable roentgenologically for many weeks or months.

The present report is concerned largely with the roentgen features of the disease. Most of the cases have already been described from the clinical and pathogenetic points of view by Harkavy (4, 5).

CASE REPORTS

The first three cases are examples of the relatively benign group, and the last two illustrate the more complicated and malignant forms of the disease.

CASE 1 (Fig. 1): F. B., a young woman, first came under observation in February 1934 at the age of 21, fifteen months after the onset of an acute illness characterized by high fever for ten days, followed by cough, weakness, and loss of weight, requiring a convalescent period of two months. At that time, because some cough and weakness persisted, an x-ray examination of the chest was made, which disclosed extensive bilateral exudative lesions. A diagnosis of pulmonary tuberculosis was made, and the patient was sent to a sanatorium, where she remained for five months. During this time the pulmonary infiltrates cleared, casting serious doubt upon the admission diagnosis of tuberculosis. After a period of apparently normal health and activity, mild constitutional symptoms with low-grade fever and cough recurred. At the same time the pulmonary infiltrates reappeared. The patient was referred to the Mount Sinai Hospital for investigation, with a diagnosis of pulmonary infection of unknown cause. By the time she was admitted the infiltrates had cleared completely. The significant findings during her short stay in the hospital were a few transient wheezing râles at both bases and an eosinophilia of 17 per cent.

During the subsequent years the patient had many recurrences of the pulmonary infiltrates with complete clearing in from a few to many weeks. Altogether she had ten recurrences from 1932 to 1939; there has been none since 1939.

[1] From the Chest Group and the Department of Radiology of the Mount Sinai Hospital, New York, N. Y. Accepted for publication in April 1944.

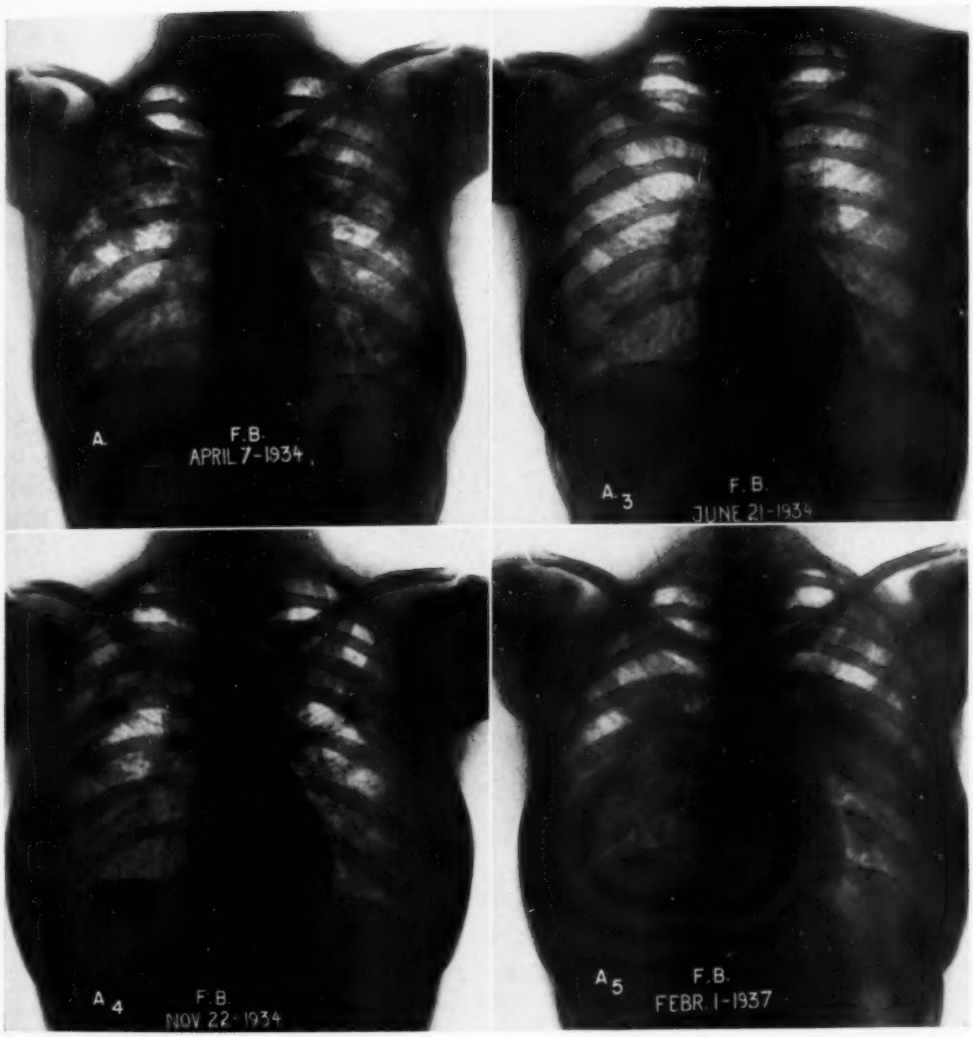

Fig. 1. Case 1. On April 7, 1934, there were nodular infiltrations throughout both lungs, particularly in the upper lobes. Some of the nodules were confluent, simulating exudative areas, as in tuberculosis. By June 21, 1934, the lungs had returned to normal. Recurrences in November 1934 and February 1937 showed patchy exudative lesions. More characteristic, however, are the irregular oblique, plate-like densities, the precise location of which has not been determined.

The other pertinent clinical features were as follows. There was a strong familial history of allergy. The patient herself had a history of recurrent sinus infection with roentgen evidence of disease in the antra and sphenoid sinuses and eosinophilia varying from 17 to 54 per cent during "attacks." Eosinophils were also present in the sputum. Positive cutaneous reactions were elicited to foods, pollens, and to bacterial products obtained from sinus washings. In 1937, for the first time, the patient exhibited typical attacks of bronchial asthma. She was treated (Dr. Harkavy) with vaccine and pollen extracts and has been entirely well since 1939.

CASE 2 (Fig. 2): E. E., a woman of 28, first came under observation in May 1942, with a history of recurring attacks of bronchial asthma of moderate severity for ten years. During the ten weeks prior to her admission to the Mount Sinai Hospital, she had two or three severe asthmatic paroxysms daily, associated with fever up to 101° F. and a cough productive of abundant mucopurulent sputum. Because of the roentgen appearance of the lungs, pul-

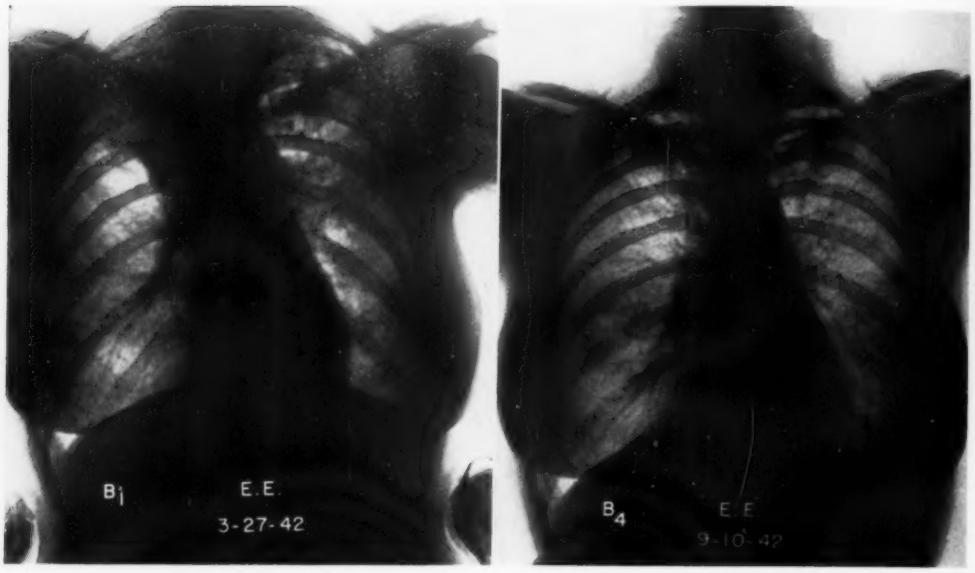

Fig. 2. Case 2. Exudative lesion in the right upper lobe. There is no evidence of contraction of the lobe. Indefinite nodular infiltrations in the left upper lobe. Six months later, the lesion had largely disappeared.

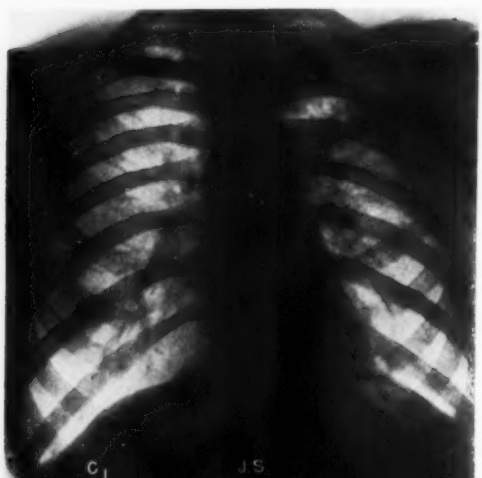

Fig. 3. Case 3. Exudative lesion in the left upper lobe with a characteristic irregular oblique density in the lateral third of the chest. There are indefinite nodular infiltrations in the left upper lobe.

monary tuberculosis was diagnosed. However, 12 sputum examinations by the concentration method failed to show the presence of tubercle bacilli. Blood examination revealed an eosinophilia of 42 per cent.

The infiltrates in the lungs largely resolved during the ensuing months. Complete investigation of the case disclosed chronic sinus disease and marked sensitivity to pollens, foods, and bacterial products from the material obtained from the sinus washings. Treatment has resulted in improvement in the asthma. There has been no recurrence of the pulmonary infiltrates to date.

CASE 3 (Fig. 3): The patient was a man of 27 years, who had recurring episodes of bronchial asthma for one year. At the end of April 1942, an upper respiratory infection developed, which was followed by fever of 102° F., a non-productive cough, and loss of 12 pounds in weight over a period of four weeks. Interestingly enough, during this acute illness the asthmatic attacks ceased. Study at another clinic revealed extensive pulmonary infiltrates, and a diagnosis of active pulmonary tuberculosis was made. However, all examinations for confirmatory evidence of active pulmonary tuberculosis yielded negative results. Because of the unusual and, in a sense, characteristic roentgen appearance of the lungs, the blood was examined for eosinophilia and revealed 46 per cent eosinophilic leukocytes.

The patient made a gradual but uneventful recovery, with complete resolution of the pulmonary exudates about two and a half months after their first appearance. He has remained well.

CASE 4 (Fig. 4): This case is one of transient and recurrent pulmonary infiltrates appearing in the lungs of a girl of 19 with a blood eosinophilia up to 39 per cent. She came under our observation first in 1940, with a history of recurring bouts of asthma for three years. During the ensuing year she exhibited the following additional significant clinical

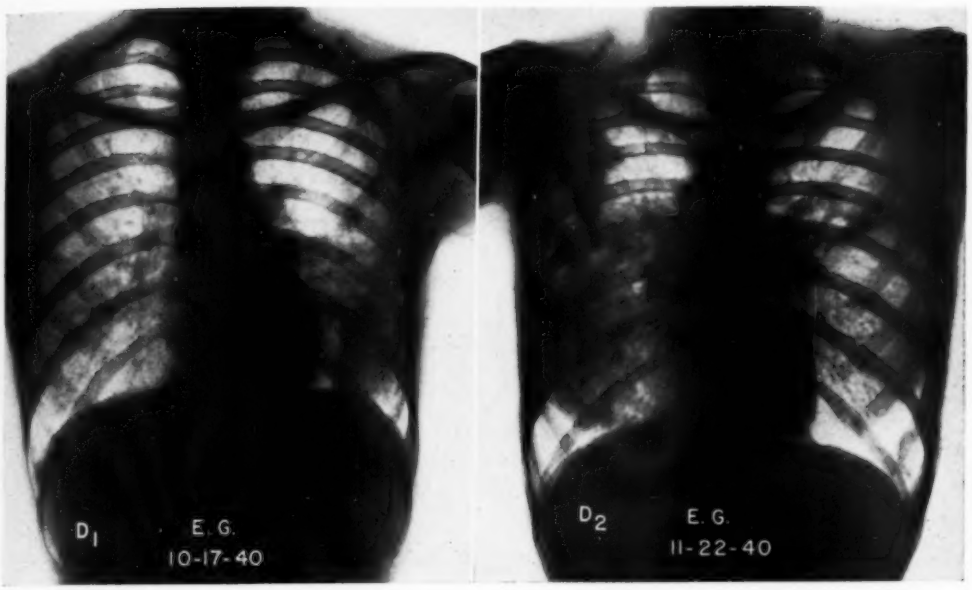

Fig. 4. Case 4. On Oct. 17, 1940, there were irregular exudative lesions in the left lower lung, within which was an oblique homogeneous streak. By Nov. 22, 1940, the left base was clear, but a similar lesion was present in the right chest.

manifestations: recurring episodes of asthma, abdominal pain, and bouts of diarrhea with five to seven watery stools a day, occasionally with mucus and blood streaks; eosinophils in the sputum; a small pleural effusion, with 85 to 100 per cent eosinophilic leukocytes in the fluid; pain and tenderness in the muscles later followed by weakness, paralysis, and purpuric spots on the skin. Electrocardiographic changes were suggestive of myocardial disease. Biopsy of a skin lesion showed eosinophilic infiltrations about blood vessels and nerves. Death was due to cardiac failure.

No necropsy was obtained in this case. In another case, however, with a practically identical clinical picture and course, the significant necropsy findings were as follows: eosinophilic infitlrations in the interalveolar septa of the lungs; endarteritis obliterans of the pulmonary blood vessels; diffuse eosinophilic infiltrations in the heart muscle, the intestines, and the abdominal muscles; diffuse involvement of small and medium-sized arteries in various organs, including such changes as intimal thickening, infiltration with many eosinophilic leukocytes, endarteritis obliterans, necrotizing arteritis, and periarteritis.

Case 4 thus illustrates the transition from the simple variety of the so-called Löffler syndrome to the condition characterized as diffuse vascular disease.

CASE 5 (Figs. 5 and 6). L. C., a Puerto Rican woman of 26, was seen in June 1942, with a ten-year history of chronic sinusitis and a three-year history of recurring bronchial asthma. During the three months preceding admission, she had fever up to 102° F. and experienced numerous asthmatic attacks. On admission she showed widespread infiltrations in both lungs. A leukocytosis of 24,000 to 36,000 with 42 to 68 per cent eosinophils was found. The patient remained under observation until Feb. 1, 1943, during which time roentgenograms of the lungs showed alternating clearing and recurrence of the exudates. The cardiac shadow became larger. The eosinophilia fluctuated with the pulmonary changes. During the same period arthritic symptoms developed. Signs and symptoms of cardiac involvement appeared with recurring episodes of right heart failure and there were electrocardiographic changes indicative of myocardial damage. Tender nodules as large as a pea were palpable along the course of the blood vessels. Severe abdominal symptoms appeared, as well as variable neurological complaints. Asthmatic attacks continued to be frequent and severe. The general condition showed progressive deterioration. Biopsy of skin and muscle showed a necrotizing arteritis as seen in periarteritis nodosa.

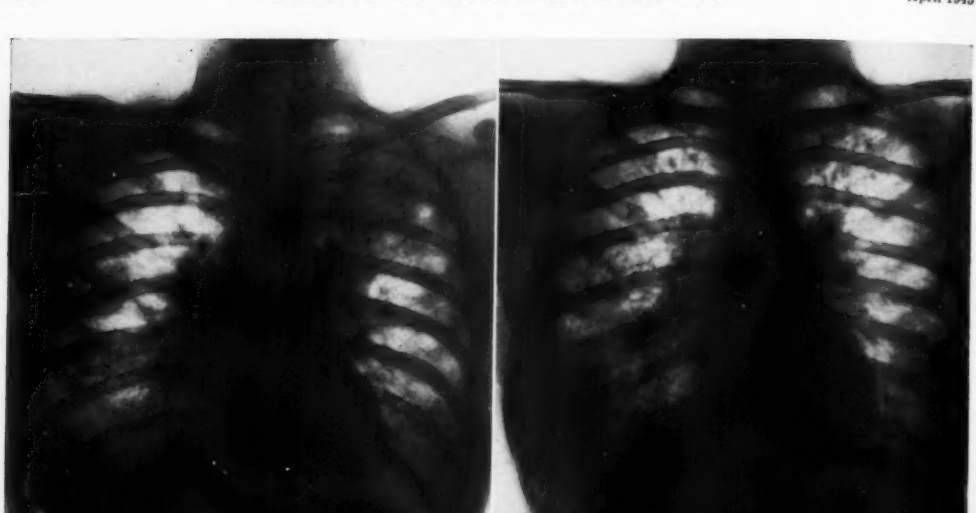

Fig. 5. Case 5. On June 11, 1942, there were nodular and confluent infiltrations in the left upper lobe, at the root of the right lung, and in the right lower lobe. Thirteen days later, the left upper lobe and root of the right lung were practically clear, but the right lower lobe was involved more extensively.

In Case 5 the transient and recurring pulmonary exudates with eosinophilia occurring in an asthmatic patient originally led to a diagnosis of simple eosinophilic pneumonia. The subsequent course of the case indicated involvement of the joints, heart, and blood vessels elsewhere in the body, such as occurs in periarteritis nodosa.

ROENTGEN FINDINGS

In our experience, the eosinophilic infiltrations are of homogeneous density and varying size. They may be confluent, resulting in a patchy appearance or, if they are extensively confluent, resembling lobar consolidation. Sometimes there is an appearance of radiation from the hilum, but usually there are associated confluent patches at the periphery. Complete resolution usually takes place, but a few linear strands may remain. In this form, the roentgen appearance is not characteristic. Tuberculosis or suppurative bronchopneumonia may be simulated. Certain phases in the course of Boeck's sarcoid are also similar. Frequently during the progress of the disease, however, narrow, plate-like homogeneous densities are seen extending obliquely caudad and laterally. Often they are symmetrical in the two lungs. They also resolve completely. Whether they represent localized exudations in the lung or in the pleura is impossible to state, but they seem to be unique to this disease. There is no predilection for upper or lower lobes, but a fair degree of symmetry on the two sides is the rule. Evidences of atelectasis, calcification, and cavity formation are entirely lacking. Nodular infiltrations where the nodules are of nearly equal size have not been seen by us but have been described by others. Hilar adenopathy is not apparent.

DISCUSSION

A brief discussion of etiology and pathogenesis of eosinophilic pulmonary infiltrations is of aid in an understanding of the roentgen findings. An allergic origin has been suspected by most observers. Löffler stressed the importance of tuberculotoxins but did not exclude the possibility of other allergenic factors. Leitner believed that

the fleeting pulmonary infiltrates with eosinophilia were hyperergic in character and were due to different causes, including allergic reactions about tuberculous lesions. Ascaris and amebiasis may furnish the specific allergens causing the symptoms in certain cases, while in others bacterial toxins, foods, or pollens may be the responsible factors.

Because of the benign character of most of the reported cases, there has been little opportunity to study at postmortem examination the nature of the pathological process in the lungs during the active phase. In some of the reported cases histologic examination of the bone marrow and of excised lymph nodes showed hyperplasia and infiltration with many eosinophilic leukocytes. The inference was drawn that the shadows in the lung were probably due to similar infiltration of the lung tissue with eosinophilic cells.

H. v. Meyenburg (6) had the unique opportunity to observe the postmortem findings in 4 cases with fleeting lung infiltrates during the active phase. Three patients died after accidental injury and one of acute tetanus. The gross appearance of the pulmonary foci was not characteristic. They resembled focal pneumonias of varying form, size, and distribution. Microscopically all these cases showed a high grade of eosinophilia in the inflammatory exudate. In 2 cases there was also an eosinophilic bronchitis and bronchiolitis. Charcot-Leyden crystals were found in one of the pulmonic infiltrates. Eosinophilia of the blood and bone marrow was present in all cases. In 2 of the cases eosinophilic infiltrates were found also in the liver.

In a series of reports under the title "Vascular Allergy" (4, 5), Harkavy described recently 16 cases which were observed for long periods of time and were studied with great care, including biopsy and postmortem observations. All of his cases showed eosinophilia and the transient pulmonary exudates which characterize the syndrome under discussion. Many of the cases, however, showed other interesting

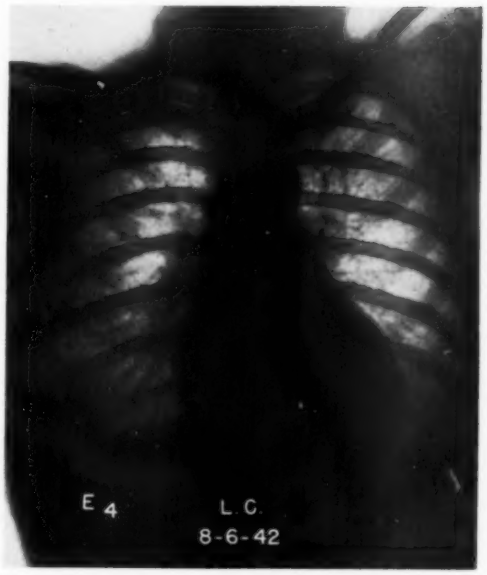

Fig. 6. Case 5. By Aug. 6, 1942, the lungs were practically clear, but the cardiac shadow was distinctly increased in size. There were associated episodes of right heart failure.

features, some of which were not previously described. An allergic background was present in all cases. The pulmonary infiltrates lasted for long periods, weeks or months instead of days, and in one case recurred as many as ten times. The associated clinical features were not always mild, and in some instances proved fatal. In many of the cases there were analogous exudative reactions in other tissues and organs, as the pleura, the pericardium, the peritoneum, the heart muscle, the skin, the joints. Examination of the pleural and peritoneal exudates showed 85 to 100 per cent eosinophils. Biopsy of skin lesions showed eosinophilic infiltrations as an important element of the lesion. Some patients died, and postmortem examination revealed eosinophilic infiltration in the lungs, heart muscle, and other organs involved, as well as various types of arteritis and periarteritis.

The roentgen findings in the chest can thus be attributed to an exudative reaction in the lungs and pleura, perhaps analogous in character to the wheal formation ob-

served in the skin. It is in this way that the homogeneous density of the scattered and oblique plate-like areas can best be explained.

SUMMARY

1. A description of the clinical and roentgen features of eosinophilic infiltrates in the lungs has been presented.

2. The resemblance of the pulmonary infiltrates to the lesions seen in exudative tuberculosis has led to an erroneous diagnosis of atypical pulmonary tuberculosis in many instances. The bizarre distribution of the pulmonary densities is quite characteristic and should suggest the correct diagnosis; the finding of an eosinophilia will confirm it.

3. These pulmonary infiltrates frequently resolve in a few days, but they may last for weeks and months. They may also recur many times.

4. There is a definite allergic background in most if not all of the cases, which suggests an allergic basis for this condition. A multiplicity of allergenic factors may be responsible for it.

5. The associated clinical features may be mild and of short duration. They may also be of moderate severity and last for weeks and months.

6. In some cases there may be an analogous exudative reaction in other organs and tissues. A fatal issue may result if important organs are severely involved.

7. Recurrent and transient pulmonary infiltrates with eosinophilia may represent one manifestation or phase of vascular allergy (Harkavy).

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Chronic Massive Pericardial Effusion Following Roentgen Therapy for Carcinoma of the Breast[1]

With a Case Report

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CHRONIC pericardial effusion following a single massive dose of x-rays appears to be extremely rare. We have not been able to find any reported case in an extensive search of the literature. The effects of irradiation on the heart and its coverings have been discussed by Leach (13) in a recent study of 85 cases and by Leucutia (14) in an editorial. These authors have reviewed the essential clinical and experimental findings.

Leucutia states: "For the present, we can safely make the premise that no damage is being done to the heart itself by the various methods of irradiation as currently used in roentgen therapy." While this generalization may normally be valid, complications arising from injudicious therapy must always be kept in mind. These possibilities may be explored with the aid of animal experiments and answered more fully by carefully recording observations of the effects of the rays on the patient. Close correlation of the clinical observations with the pathological findings is essential in cases in which doses massive enough to produce lesions of some magnitude have been administered. Thus will the appropriate critical tolerance dose which will not produce damaging changes be discovered.

We had the opportunity of observing the effects of a single massive dose of x-rays given in such a way that the minimum of tissue lay between the incident beam and the heart. The position and the body build (short and obese) of the patient brought the heart and its coverings to within 2 or 3 cm. of the measured surface treated. A short preoperative course was given, consisting of three treatments totaling 600 r (in air) to a circular field, 25 cm. in diameter, on the anterior left chest. The posterior axilla was treated with a single 300 r exposure to a 15-cm. circular field. At the time of operation a single dose, thought to be 3,000 r (in air), was directed to a 12 × 14-cm. area through the open wound. Review of the original treatment record leads us to believe that the exposure at the surface of the chest wall (flayed) may have been 3,600 r (in air). Estimating scattering and absorption, the tissue dose in the pericardium where it lay closest to the surface—2 to 3 cm.—may have reached 3,800 r. This tissue dose of 3,800 r given in one session is probably equal to a tissue dose of 7,600 r delivered in ten minutes over a ten-day period (Pack and Quimby, 16). Added to this single massive dose was a certain amount of radiation from the preoperative course (which undoubtedly included the left half of the cardiac area), an increment of perhaps 650 tissue roentgens in four days, or a total estimated tissue dose of 8,250 r in a period of nine days.

CASE REPORT

On Aug. 22, 1939, a plump Korean woman of 53 years entered San Francisco Hospital complaining of masses in the left breast and axilla of one month's duration. The mass in the upper outer quadrant of the left breast measured 7 cm. in diameter and was attached to the skin and deep tissues. A large semi-fixed axillary node was palpated. The remainder of the physical examination and the laboratory findings showed nothing unusual except for a hypertension of 220/95. X-ray examination of the chest was negative (Fig. 1).

From Aug. 24 to Aug. 28, the patient received three doses of x-rays, a total of 600 r (in air), to a 25-cm. field including the left breast and axilla, at 70 cm., with 200 kv., and 0.5 mm. Cu and 1 mm. Al filtration (giving a half-value layer of 1.0 mm. Cu).

[1] From the Departments of Pathology and Radiology, Stanford University School of Medicine, and the Department of Public Health of San Francisco. Accepted for publication in July 1944.

Fig. 1. Roentgenogram made Aug. 24, 1939. The lungs are clear and the cardiac silhouette is not unusual. The bony thorax is intact.

She also received a single dose of 300 r to the posterior axilla (circular field 15 cm. in diameter) with the same factors.

On Sept. 2, a left radical mastectomy for medullary carcinoma of the breast was performed. During the operation the patient was exposed to a dose of approximately 3,600 r in air (time, 15 minutes; 12 × 14-cm. field; 40 cm. distance; 200 kv.; no filter; half-value layer 0.35 mm. Cu) for the purpose of "sterilizing" any residual cancer cells at the operative site. The x-rays were directed into the open wound on the left chest wall and axilla at the level of the 4th, 5th, and 6th ribs, the skin edges being protected by a thin sheet of lead. The patient was returned to surgery and the wound was closed. Following an uneventful recovery, she was discharged Oct. 7, 1939.

On March 27, 1940, the patient complained of cough with some tightness in the left shoulder and pain down the left arm. X-ray examination showed a shadow interpreted as roentgen pneumonitis (Fig. 2). The weight, not previously recorded, was 148 pounds.

On Oct. 9, 1940, abdominal distress was reported. The liver edge was palpated two finger breadths below the costal margin.

During the succeeding year the patient lost 25 pounds, and cough and abdominal discomfort persisted. On Oct. 15, 1941, exertional dyspnea was noticed for the first time. The liver edge was still palpable.

In the following two years all of the symptoms persisted and on Feb. 26, 1942, extensive mediastinal and pericardial metastasis was suspected (Fig. 3). There had been a steady loss of weight to 102 pounds.

On Feb. 5, 1944, the patient re-entered San Francisco Hospital suffering from abdominal distress, swelling of the legs, and exertional dyspnea. Physical examination showed a thin, dyspneic, middle-aged woman with moderate venous distention in the neck. The mastectomy scar was smooth, and there was no evidence of a local recurrence of the tumor. There was dullness with decreased breath sounds over the left chest. The heart was enlarged to percussion to the left anterior axillary line. Occasional premature systoles and a rough systolic murmur were heard. The liver was felt three finger

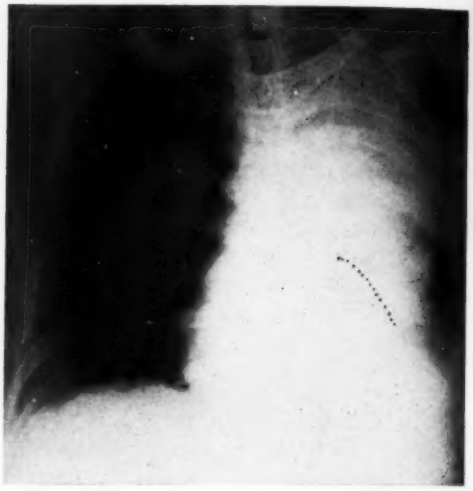

Fig. 2. Roentgenogram made March 27, 1940, seven months after roentgen therapy. The consolidation of the upper half of the left lung is obvious. There is blunting of the left costophrenic angle. The right lung remains clear. There is no displacement of the trachea. The fullness of the cardiac shadow is clearly seen to the right as compared with the earlier film (Fig. 1). The left cardiac border cannot be clearly seen in this reproduction, but a dotted line has been used to show its location on the original film. The enlarged cardiac shadow was noted only in retrospect. The bony thorax is still intact. (Note in this and the subsequent reproductions the descent of the leaves of the diaphragm as the patient loses weight.)

breadths below the right costal margin. There was pitting edema of the lower extremities and sacral region. The blood pressure was 170/100. The ECG showed a P-R interval of 0.17 seconds; slurring and low voltage of QRS in all leads but normal duration; ST 1, 2 and 4 depressed 1 mm. with small upright T 1, 2 and 4; ST 3 isoelectric with almost flat T 3. The electrocardiographic findings were interpreted as indicative of mild myocardial damage.

On bed rest, the edema decreased and the circulation time fell from 35 seconds on Feb. 6 to 20 seconds on Feb. 14. On Feb. 18, the condition changed suddenly for the worse and respiration became grunting. The venous pressure was recorded at 18 cm. of water, and the circulation time increased to 27 seconds. An ECG showed no change from previous findings.

On March 10, 1944, the blood pressure was 115/75 and the neck vessels were dilated and pulsating. On

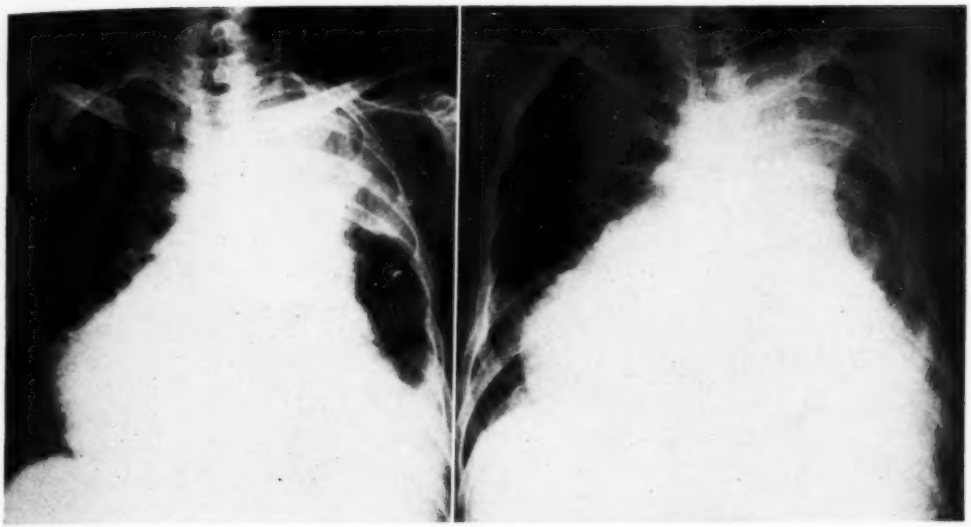

Fig. 3 (left). Roentgenogram made Feb. 26, 1942, two and a half years after irradiation, showing slight diminution in the consolidation of the left upper lobe. The blunted left costophrenic angle persists. The trachea remains unchanged. The cardiac silhouette is now tremendous, extending far to the right of the mid-line. It was thought at the time that the patient was suffering from metastatic carcinoma. Now for the first time the thinning of the ribs along the lateral chest wall is demonstrated.

Fig. 4 (right). Roentgenogram made March 10, 1944, four and a half years after irradiation. The film reveals no great change in the airless upper half of the left lung and the costophrenic angle. The right lung now shows increase in the vascular markings and areas of patchy consolidation. The cardiac silhouette has a typical "water-bottle" appearance and extends from 1.5 cm. within the left chest wall to within 2 cm. of the right chest wall. Six of the atrophied ribs show fractures—the 2nd, 3rd, 4th, 5th, 6th, and 7th.

the following day the patient was in shock, with a blood pressure of 84/68, pulse rate of 110, and faint heart sounds. A pericardial tap removed 310 c.c. of brownish fluid, which was under considerable pressure and clotted almost immediately; this was replaced by air (Fig. 5). Death occurred within two hours following the tap.

Autopsy: At autopsy the borders of the pericardium were found at the right midclavicular line and the left anterior axillary line. There were 350 c.c. of serofibrinous fluid in the left pleural cavity. Fractures of the 2d rib anteriorly and 3d, 4th, 5th, 6th, and 7th ribs laterally were present. The pericardial sac was distended with 300 c.c. of fluid and air. The parietal pericardium was dilated and thickened (2 to 3 mm.) by opaque fibrous tissue, and wrinkled on its inner surface, giving the appearance of elephant skin (Fig. 6). It contained 2 small opaque nodules 1–2 mm. in diameter. The visceral pericardium showed less thickening and there was a distinct difference between the thickness of the left anterior portion and of the right posterior area. The heart weighed 320 gm. The myocardium was tough throughout, although no gross fibrosis was seen. The left lung was small. The upper lobe and the upper part of the lower lobe were composed, principally, of bronchi and vessels separated by only a small

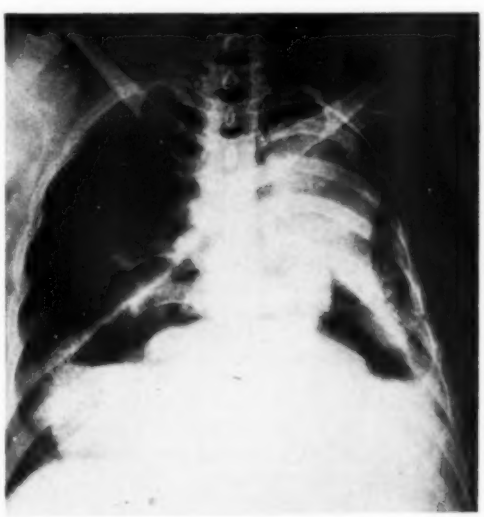

Fig. 5. Roentgenogram made March 11, 1944, after removal of 310 c.c. of pericardial fluid and replacement with air. The film reveals the large thick-walled pericardial sac. The patient died within two hours following the tap.

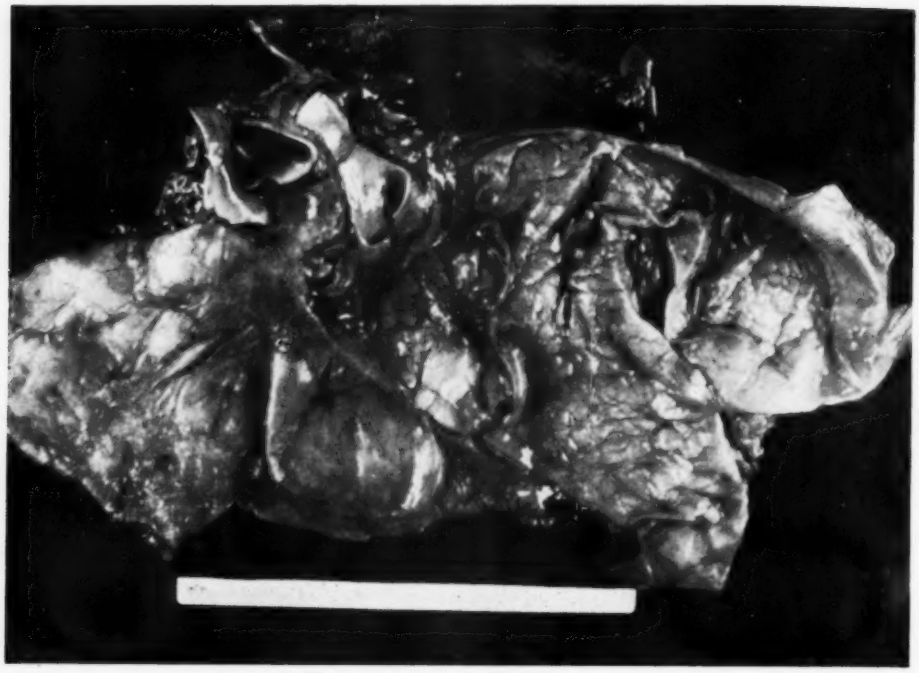

Fig. 6. Excised parietal pericardium showing thickening and wrinkling which produce the superficial appearance of elephant skin.

amount of collapsed lung tissue. Bronchopneumonic consolidation was present in the right lung and left lower lobe.

Microscopically there was widespread focal fibrosis of the myocardium in all the chambers of the heart, most marked in the left auricle and ventricle. Some of the coronary artery radicles showed intimal proliferation but others showed none. The pericardium contained much dense hyalinized fibrous tissue in the parietal and visceral layers; in places small dilated thin-walled vessels were prominent. The fibrosis of the visceral pericardium was more marked on the left. In two nodules seen grossly there was evidence of old hemorrhage. A number of large discrete fibroblasts with large, bizarre, somewhat irregular deeply stained nuclei were seen in the fibrous tissue of both the pericardium and myocardium. The upper lobe and upper part of the lower lobe were almost completely collapsed. Their substance was firm, and histologically there was much thickening of the alveolar septa, where elastic tissue was abundant. There was mild diffuse increase in fibrous tissue and some large fibroblasts similar to those described in the myocardium and pericardium were seen in the lung and pleura. Many small vessels were dilated, and several medium-sized branches of the pulmonary artery contained canalized thrombi. Acute bronchopneumonia was present in both lungs. The pleura showed fibrous thickening with superimposed acute inflammatory reaction. Sections of the ribs at and adjacent to the fracture zones revealed fibrous replacement of bone marrow, with atrophy of the cortex and bone spicules.

It was concluded that the remarkable fibrous thickening of the pericardium which showed no specific inflammatory reaction was probably the result of the unusually intense irradiation of this region at the time of the left mastectomy. The mechanical interference with the heart movement was the principal cause of circulatory failure and the final illness. The left lung was extensively collapsed, presumably as a result of irradiation, although fibrosis was not marked. No tumor was found.

COMMENT

The literature abounds with references (Warren, 19; Desjardins, 3) to the changes in the myocardium following irradiation, but heretofore only passing mention has been made of the occurrence of small effusions and the effects of irradiation on the pericardium (Freid and Goldberg, 6; Davis, 2; Hartman *et al.* 11). Granzow (10)

is the only investigator who has described changes in the pericardium similar to those in our case. He emphasizes the necrotizing effect of the rays upon the pericardium in guinea-pigs.

The exact mechanism of the development of pericardial effusion in our case cannot be determined, but, for the following reasons, it appears to have resulted directly or indirectly from the irradiation: the amount of radiation reaching the pericardium in a short time was large; the pathological changes were unusual and included telangiectases in the scar as well as an alteration in fibroblasts similar to that frequently reported in radiation reactions (Maximow, 15); there were associated changes in the ribs and in the left lung compatible with a roentgen reaction; the changes have a counterpart in the experimental observations of Granzow (10), Davis (2), Hartman and others (11) in irradiated animals; finally, no other satisfactory explanation for the changes has been found. One factor may have been the occlusive effect of x-rays upon the lymphatics (Gassmann, 7 and 8) and blood vessels (Baermann and Linsen, 1). The damage to the parietal pericardium, in view of the fact that this structure plays the greater part in absorption of fluid from the pericardial cavity (Henke and Lubarsch, 12), appears to be a significant factor in the production and persistence of the massive effusion. The occurrence of bizarre fibroblasts (Maximow, 15) confirms the direct effect of the x-rays upon the pericardium. The greater degree of damage (fibrous thickening) of the left side of the visceral pericardium as compared to the right is in correspondence with the greater severity of myocardial lesions on the left, *i.e.*, in the path of greatest intensity of the x-rays, which were directed obliquely from left to right.

The histologic observations on the myocardium conform to the microscopic experimental and clinical findings described by Warthin and Pohle (20 and 21); Freid and Goldberg (6); Davis (2); Granzow (10); Werthemann (22), and Domagk (4).

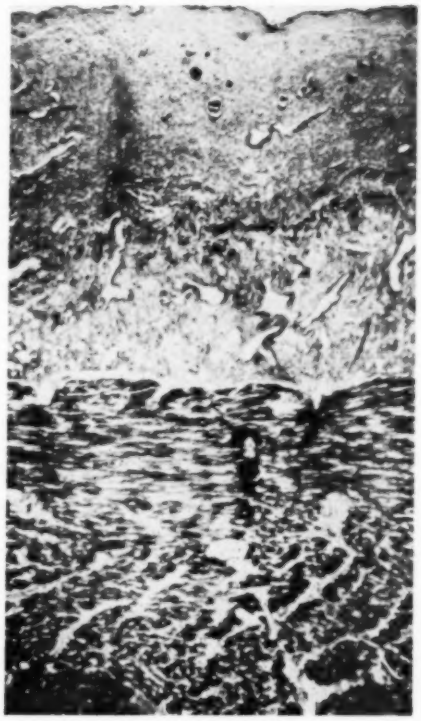

Fig. 7. Photomicrograph of left ventricle, showing fibrous thickening of the visceral pericardium to 2 to 3 mm. A narrow border of epicardial fat remains, but here also fibrosis is seen. The irregular blurred appearance of the myocardium is due to the patchy character of the fibrosis. Azocarmine-aniline blue stain. × 65.

All report varying degrees of myocardial damage, with emphasis on the patchy character of the changes originally described by Schweizer (18), who believed that the microscopic picture is specific. Our findings are at variance with the conclusions reached by Gordon *et al.* (9), Emery and Gordon (5), and Leucutia (14), denying a significant effect of x-rays upon the myocardium. The possibility that the changes in our case might have been on the basis of long standing pericardial effusion, with compression of the heart, has been taken into consideration. Roberts and Beck (17), however, investigated the effect of long standing constriction on the heart and observed only atrophy of the heart muscle fibers.

SUMMARY

A case of pericardial effusion of four and a half years' duration following a single massive dose of x-rays is presented, with autopsy findings.

The treatment was through an open mastectomy wound. The total estimated dose in the pericardium was 8,250 tissue r.

The pathological changes in the heart, especially the pericardium, are described and discussed.

Damage to the parietal pericardium is believed to have been a significant factor in the production and persistence of the effusion.

CONCLUSIONS

This appears to be the first reported case of massive pericardial effusion of long duration, following irradiation.

Chronic pericardial hydrops can be produced by a single massive dose of irradiation to the opened thoracic wall. This hydrops can be of such severity as to be the primary cause of death.

Massive irradiation of the open thorax (as a step in the control of mammary and other neoplasms) with the doses employed in this case is not to be recommended.

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Observations on Over One Hundred Cases of Myelogenous and Lymphatic Leukemia

With Blood and Sternal Puncture Studies and Follow-Up of Several Years[1]

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THE LEUKEMIAS constitute a subdivision in the group of reticulo-endothelial neoplasias and present symptoms and clinical features which closely parallel those of the entire group. In order of the approximate frequency of their appearance, the reticulo-endothelial neoplasias can be listed as follows:

1. Leukemias (myelogenous, lymphogenous, monocytic, etc.)
2. Lymphosarcoma, including reticulum-cell sarcoma, large- and small-cell lymphosarcoma.
3. Malignant lymphadenoma or Hodgkin's disease.
4. Multiple myeloma, plasma-cell myeloma.
5. Endothelioma.
6. Ewing's tumor or endothelial myeloma of bone.
7. Tumors of the storage reticulum, including Niemann-Pick disease, Schüller-Christian's disease, Gaucher's disease.

Except in the case of the storage-cell tumors, the life expectancy, type of morbidity, and response to radiation or drug therapy follow a closely similar pattern in all these diseases, though there are numerous individual variations by virtue of which the subclassifications have arisen. In the well established individual groups, the morphologic picture as seen on microscopic section is characteristic for each group. These groups, however, so overlap histologically that frequently at some time during their respective courses they are histologically inseparable. This becomes particularly evident when an attempt is made to interpret lymph node biopsy in the lymphosarcoma or leukemia groups without foreknowledge of the blood picture. The use of bone marrow studies as a routine procedure has been a valuable aid in separating the lymphosarcomas from the leukemic cases.

The etiology of leukemic disease is entirely unknown and therefore there is no specific treatment. For a limited period of time the manifestations may be more or less localized but eventually, if the patient survives long enough, the condition will become generalized. This general distribution of the disease is not an instance of metastasis but one of multiple spontaneous manifestations. The existence of reticulo-endothelial cellular elements in practically every part of the body permits the development of the specific lesions within any of its structures. We therefore see leukemic nodular infiltration in the skin, in bone, in fascial planes, in any and all the viscera, in muscle structure, in the mucosa of the mouth, vagina, endometrium, etc.

This widespread distribution of disease is important in considering radiation therapeutic procedure. The dosage must remain as small as is compatible with relief of symptoms. Nothing is gained by over-irradiation. It is not unusual to see radiation resistance developing in a case that has been excessively irradiated. The indications for treatment by radiation, or by drugs, or by transfusion, are purely palliative. Pressure from enlarged lymph nodes

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and pain from splenic enlargement or from bone infiltration point to the need for irradiation, as do malaise, easy fatigue, weakness, and moderate temperature elevation. Symptoms of nitrogen retention, varying from malaise to the pre-uremic or uremic state, are helped by irradiation of the kidneys, through reduction of the leukemic infiltration of the renal parenchyma and the incident mechanical embarrassment of the glomeruli and tubules. Nemenow, Jugenberg *et al.* demonstrated an increase in uric acid excretion after kidney irradiation in advanced leukemia and described a uric acid index. A pronounced leukopenic blood picture is a contraindication to irradiation. An acute leukemic blood picture is not favorably influenced by radiation. The value of the leukocyte count in the saliva, as described by Isaacs, could not be borne out in our study.

In the series of cases reviewed, the bone marrow in the majority of instances was studied repeatedly. All examinations were made by the aspiration method made popular by Vogel, Erf, and Rosenthal. Briefly, this consists, in adults, of withdrawing about 1 c.c. of marrow from the cavity of the sternum at the level of the third interspace. Total nucleated cell and megakaryocyte counts were made and differential smears examined. In children, the tibial marrow cavity was used, since this presented less difficulty. In addition, it was found that the tibial space is larger in children than that of the sternum and the possibility of injury to the underlying structures is therefore less. A careful survey of all our material to date indicates that in every case of leukemia coming to our attention the bone marrow of the sternum or tibia was involved to the extent that there was never any question of diagnosis. While it is true that some of our patients were brought to us in late or terminal stages, there were many others in whom the diagnosis was made only after blood and marrow studies. This suggests that the bone marrow must be involved before the disease becomes clinically manifest. Several cases included in this study were referred to the Hematological Clinic of the Radiation Therapy Department with a biopsy diagnosis of lymphosarcoma and indefinite peripheral blood counts only to be proved, first by sternal puncture and later by the course of the disease, to be lymphatic leukemia. We are impressed by the probability that the marrow picture will prove to be the earliest and most accurate factor in the differential diagnosis.

The lymphocyte count in the sternal bone marrow in lymphatic leukemias varied between 23 and 96 per cent of all the white blood cells present. The normal bone marrow shows from 8 to 13 per cent lymphocytes. Cases believed on biopsy to be lymphosarcoma but showing bone marrow lymphocyte counts of 23 per cent or more proved subsequently to be lymphatic leukemia.

Bone-marrow studies are an essential part of the investigation of the reticuloendothelial diseases not only for the diagnosis of lymphatic leukemia but also for the recognition of several other diseases in this general group. Plasma-cell myeloma and Gaucher's disease can be recognized rather simply on bone-marrow puncture.

This review is based on 105 cases of leukemia seen between 1939 and 1941 in the Radiation Therapy Department of Kings County Hospital. Of these cases, 51 were lymphatic leukemia and 53 were myelogenous leukemia; 1 was a monocytic leukemia.

The 53 cases of myelogenous leukemia were about evenly divided between males and females. Eleven cases were hematologically and clinically acute; 42 cases were chronic. Patients with acute myelogenous leukemia survived an average of 2.5 months from the onset of illness. The longest survival was nine months, the shortest about two weeks. All the cases in children were acute, but the majority of acute leukemias are not in childhood. The average age of the patients with acute myelogenous leukemia was thirty-six years; the youngest was five years and the oldest seventy-five years of age. Of the 42 patients with chronic myelogenous leukemia, 8 are still alive. For those who died, the average

duration of illness from first symptom to death was 44.2 months. The shortest duration was eight months. Two patients survived more than six years, 3 eight years, and 1 over eleven years. The patients who are still alive are in no sense cured. They still show the blood picture and symptoms of their disease.

The lymphatic leukemias, 51 cases, were found almost twice as frequently in males as in females. Five of the cases were hematologically and clinically acute; 46 were chronic. In the acute cases the average duration of life was 4.4 months from the onset of illness. The youngest patient was eleven years old, the oldest seventy-two years. Of the 46 patients with chronic lymphatic leukemia, 10 are still alive and several of them are in the seventh year of illness. The average survival period for those who died of the disease was seventeen and a half months. This is considerably less than the expectancy in chronic myelogenous leukemia. Except for the relief of mechanical pressure symptoms which threaten life, as for instance a mediastinal mass causing dyspnea or renal infiltration causing uremia, the length of survival is not directly attributable to variations in the type of radiation therapy used.

The treatment of leukemia falls into three main categories: transfusions, drug therapy, and irradiation. The condition of the patient dictates the type of treatment. The patients with clinically mild leukemia, generally comfortable, not particularly anemic, and without definite presenting symptoms, are treated by intelligent observation. In the absence of a specific for the disease and without need for palliation, such a patient is to be encouraged and his illness made light of. As anemia appears, the liberal and frequent use of blood transfusions is recommended.

Radiation therapy as used in this series was either administered locally to the spleen or lymph node masses or to multiple fields over the long bones, or total body spray irradiation was given. The factors used were 200 kv., 0.5 mm. copper and 1.0 mm. aluminum filtration, 50 cm. focal skin distance for local fields and 150 cm. for spray irradiation. Local radiation therapy to lymph nodes or spleen was used to reduce pressure symptoms. The dosage was always small, usually a 150 to 200 r tumor dose to each area treated. The dose should be kept low and repeated only if and when local findings require it. Bone irradiation is recommended in moderately active cases without severe local pressure symptoms; 300 r is given to each of the long bones in rotation, one area being treated per day. This is repeated until each field has been given 600 r. The drop in the white blood cell count following such treatment was found to be more gradual than when the spleen was irradiated. Also, the clinical intermissions were longer following osseous irradiation. Total body irradiation was used in the advanced generalized cases and in those which had previously been treated locally but had become widespread. Because of the great amount of tissue treated, the dose must be kept small. Usually 33 r were given per treatment, rarely 50 r, but never more. The fall in the white blood cell count is very rapid and must be carefully watched before spray irradiation can be repeated.

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Ileocecal Tuberculosis[1]

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THE DIAGNOSIS of ileocecal tuberculosis requires roentgenologic confirmation. From the experience at the Triboro Hospital for Tuberculosis, it is felt that the roentgen findings are sufficiently constant to permit this diagnosis to be made with some degree of certainty.

The problem at this hospital is simplified since all patients are presumably suffering from tuberculosis. The finding of organic lesions of inflammatory nature in the ileocecal region in a tuberculous patient is strong presumptive evidence that the process here is also tuberculous. The roentgenologic task, therefore, resolves itself into determining whether organic inflammatory disease is present. A differential diagnosis must, of course, always be made. We have found, however, that other conditions may readily be ruled out by the roentgen evidence. In the random case seen in a general hospital the problem would certainly be more difficult. Nevertheless, our experience would suggest that the roentgen findings may be sufficiently constant to indicate the diagnosis under any circumstance. If the patient is known to have tuberculosis, the presumption is stronger. As a corollary to this, chest roentgenograms would be indicated in the differential diagnosis of obscure ileocecal disease.

No discussion of the clinical syndrome will be given. It is to be noted, however, that there is a wide variation in the signs and symptoms. Even in the clear-cut cases, abdominal pain is of varying constancy and intensity. Indeed, it is not uncommon to find extensive ileocecal tuberculosis at autopsy in a patient who has had no gastro-intestinal symptoms or whose other complaints were so great as to overshadow completely any abdominal manifestations. The pain, when present, is usually greatest in the right lower abdominal quadrant. On palpation, tenderness about McBurney's point is often found, although the pain may be more generally distributed. A tumefaction is occasionally present. In some cases this may be palpated only during attacks of pain, suggesting a transient volvulus at the ileocecal valve. The diagnosis of acute appendicitis requires exclusion. Diarrhea may be present in varying degrees, and occasionally the stools are bloody. Cultures of the stools may be negative for acid-fast bacilli. In one patient a search for the cause of a rapid pulse led to the discovery of extensive ileocecal disease which was giving no symptoms. The varying and uncertain clinical picture increases the diagnostic value of the roentgen study.

Direct roentgen evidence of organic disease is sought in the terminal ileum, the ileocecal valve, and the cecum. Indirect confirmatory evidence is furnished by the remainder of the ileum, the appendix, and the remainder of the colon, all of which may be involved. Important evidence is likewise contributed by the psoas shadows; the right psoas shadow is frequently obliterated, possibly by regional lymph nodes or tumefaction. An associated amyloid disease or hematogenous spread may be reflected in an enlarged spleen or liver, both of which can be seen on abdominal roentgenograms.

The method of examination includes hourly fractional studies of the small intestine, continued until the ileocecal region is clearly visualized. In one instance we were not able to demonstrate the terminal ileum well until the tenth hour. Barium

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[1] From the service of Dr. A. L. Bachman, now serving with the Armed Forces. From the Department of Hospitals, City of New York. Accepted for publication in June 1944.

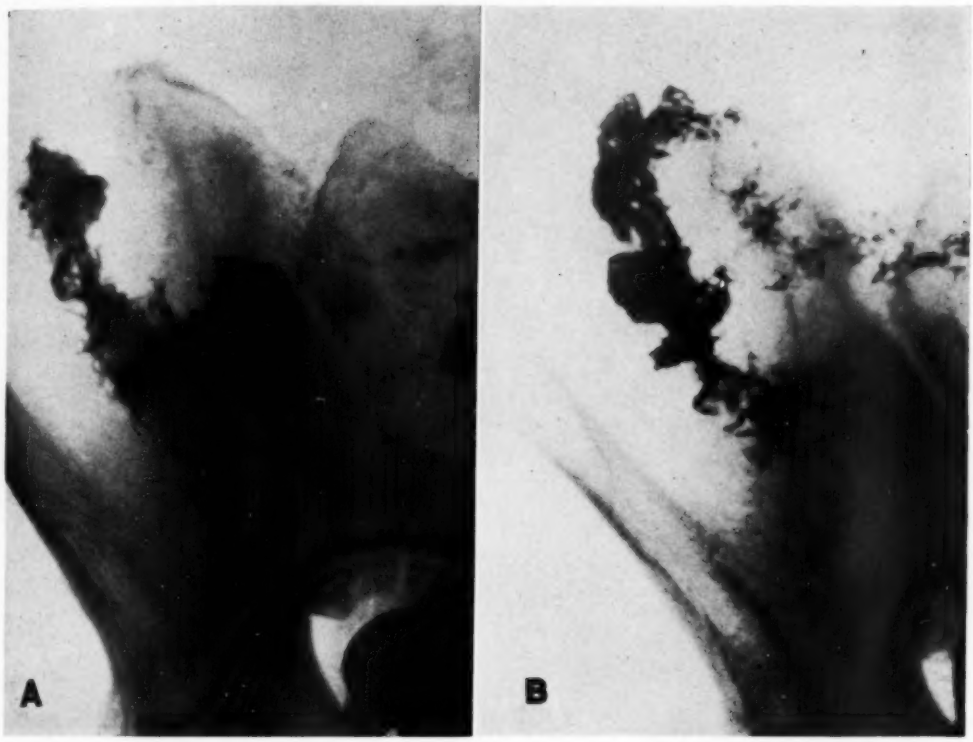

Fig. 1. Case 1: H. B., a 47-year-old female with active pulmonary tuberculosis of at least two years' duration, was referred with a diagnosis of ileocecal tuberculosis and amyloid disease. At autopsy scattered ulcers were found in the jejunum and ileum. These were closer together and more extensive in the terminal ileum; they involved the ileocecal valve and were present in the cecum. In the colon scattered ulcers extended beyond the sigmoid.

A. Roentgenogram made four hours after administration of barium by mouth, showing a cone-shaped terminal ileum with straightened, rigid walls. The cecum is spastic and deformed. The appendix, seen just below the ileum, has an irregular lumen.

B. At six hours the terminal ileum is demonstrable by its irregular, deformed lumen. The cecal spasm and deformity are more plainly shown. The appendix is fixed and deformed.

enema studies are also employed. With this procedure, the post-evacuation picture is frequently more informative than that of the barium-filled bowel. Fluoroscopy is a valuable aid. Air contrast studies are occasionally done. Spot-cone studies of the area are helpful.

ROENTGEN SIGNS AT THE TERMINAL ILEUM

The terminal few centimeters of the ileum are most frequently involved. The roentgen manifestations vary in degree with the extent and severity of the disease. Simple transient spasm may characterize very early involvement. A slight but definite mucosal pattern irregularity may be noted. Later the more typical findings are seen. There is a narrowing of the terminal portion of the ileum, sometimes with some irregularity of the wall contour. In many cases, however, the narrowing appears to be associated with a straightening and rigidity of the walls. The narrowing of the terminal ileum is frequently wedge-shaped or conical (Figs. 1, A; 2, A, B, C; 3, A, B, C; 4; 5, A), the point of the cone facing toward an irregular ileocecal valve or into the prominent lips of the valve (Fig. 5). This cone shape may be better demonstrated during fractional studies of the intestinal tract than during barium enema studies. It is best seen when there is a pressure head dilating the terminal ileum. When this area is not

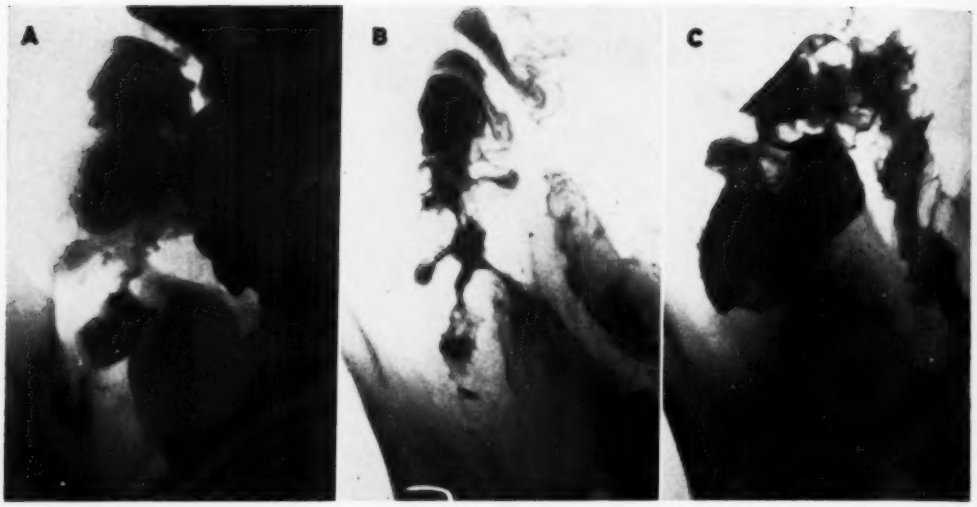

Fig. 2. Case 2: R. G., a 19-year-old white female with far advanced active pulmonary tuberculosis, complained of abdominal pain and soreness, especially in the right lower quadrant. There was tenderness to palpation over the ileocecal area.

A. Barium enema study revealing a cone-shaped deformity of the terminal few centimeters of the ileum. The mucosal pattern is lost, and the walls are straightened. The cecum is grossly deformed.

B. Post-evacuation film, clearly demonstrating the cone-shaped rigid deformity of the terminal ileum. Note, also, the gross deformity of the cecum.

C. The same area six hours after administration of barium by mouth. The cone-shaped rigid terminal ileum is seen, and severe cecal spasm is demonstrated.

Fig. 3. Case 3: J. H., a 47-year-old white male with active pulmonary tuberculosis, complained of abdominal pain and diarrhea. The pain was most severe in the right lower quadrant, where a mass the size of an orange was palpable.

A. Barium enema study showing cone-shaped deformity of the terminal few centimeters of the ileum and its straightened, rigid walls. There is some spasm in the cecum. An irregular, fixed appendiceal shadow is faintly visible below the ileum.

B. Post-evacuation film revealing delayed emptying of the ileum, with some dilatation proximal to the valve. The deformity and rigid appearance of the terminal ileum are constant. The irregular appendiceal shadow is faintly visible. The cecal spasm is more pronounced.

C. The same area six hours after administration of barium by mouth. Note the "ironed-out" appearance of the terminal ileum and its loss of mucosal pattern

Fig. 3. Case 3: D. Absence of the right psoas shadow; string-like appearance of the terminal ileum.

distended, the terminal ileum may appear as an irregular linear or string-like shadow (Figs. 1, A; 3, D; 5, C; 7, A). At times during the barium enema study, very little barium can get by the diseased valve, and the terminal portion of the ileum will be seen as a narrow string (Fig. 5, C). More evidence can be obtained from an unchanging appearance, as demonstrated by several exposures. Normally, peristaltic movement should change the pattern of the terminal ileum. An unchanging bizarre picture speaks for the existence of an organic lesion.

With more advanced disease, as described above, the mucosal pattern of the terminal ileum is usually completely disrupted. The crater of a tuberculous ulcer may be seen (Fig. 5, B). Occasionally spasm may render the ileum invisible (Fig. 6) on the random picture studied.

Summary of Signs at the Terminal Ileum:

1. Transient spasm (early)
2. Mucosal irregularity (early); loss of mucosal markings (late)
3. Narrowing

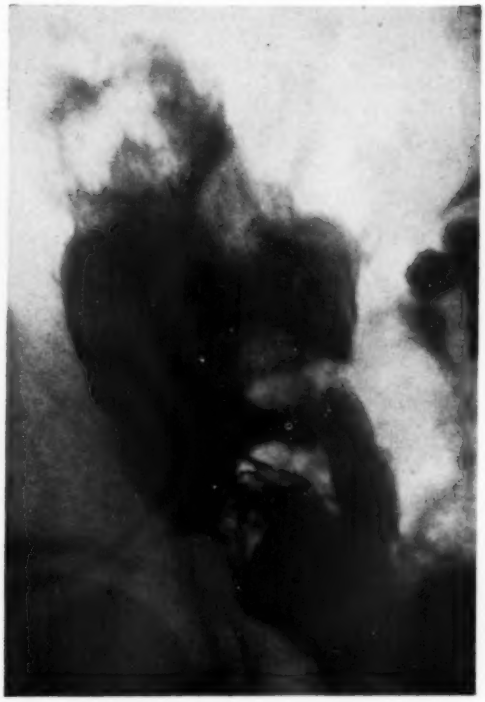

Fig. 4. Case 4: H. N., a 48-year-old white male with active pulmonary tuberculosis, died of tuberculous meningitis. While in the hospital, he complained of cramps and diarrhea, and the lower abdomen was tender. At autopsy, ulcerations were discovered in the terminal ileum, cecum, and ascending colon. One ulcer appeared to be healing, with contraction.
Note the prominence of the ileocecal valve with slight invagination of the ileum. The cecum is spastic.

4. Irregularity of the walls
5. Straightening and rigidity of the walls
6. Cone-shaped terminal portion
7. String-like appearance of the ileum
8. Loss of normal changes in appearance on serial exposures
9. An ulcer crater

ROENTGEN SIGNS AT THE ILEOCECAL VALVE

The ileocecal valve itself may appear as a negative shadow impinging upon the barium-filled cecum. The normal valve may be demonstrated in some patients. However, an edema or inflammation from any cause may make it more easily visible. Golden (1), in an interesting communica-

Fig. 5. Case 5: A. S., an 18-year-old white male, had advanced pulmonary tuberculosis. Though there were no gastro-intestinal symptoms, roentgenograms show indisputable ileocecal tuberculosis. This condition was discovered during an attempt to establish the etiology of a rapid pulse. The absence of clinical symptoms is a not unusual occurrence in this disease.

A. The roentgenogram taken two and a half hours after ingestion of barium shows extensive ileocecal tuberculosis, with ulceration throughout the entire ascending and transverse colon.

B. Detail view of ileocecal region, showing cone-shaped, rigid deformity of the last few centimeters of the ileum. The valve itself is prominent. The walls of the cecum are stiff and have a mouse-bitten contour. An ulcer niche can be seen in the ileum.

C. Barium enema study showing the same findings. Retrograde ileal filling was poor, and the terminal ileum appears as a rigid string. Note the large shadow defect produced by the ileocecal valve.

tion, recently called attention to this phenomenon. Strömbeck (2) states that the mucosal swelling in non-specific terminal ileitis is most pronounced near the valve, the two lips of which may be considerably swollen, and may bulge into the cecum. Ileocecal invagination may be related to this. A normal picture may occasionally be confusing, but when the valve is really enlarged, a pathological interpretation should be rendered. While this finding is by no means specific, it is frequently seen in ileocecal tuberculosis (Figs. 4 and 5). The conical narrowing of the terminal ileum appears, at least in part, to be due to edema and disease at the valve itself. The conical shape of the ileum should therefore be associated with other evidence of ileal disease before a pathological diagnosis of ileal disease *per se* is made.

Disease at the valve itself is reflected in functional disturbances as well as in improved visualization. The valve and terminal ileum may be gaping, with no resultant delay in the passage of contrast substance beyond this point. When the rigidity does not result in a gaping opening, inflammation, spasm, and scarring may cause delay or partial obstruction. An interesting phenomenon sometimes noted is the closure of the valve during the course of a high-pressure barium enema. With evacuation, however, the valve spasm relaxes transiently and some cecal content spurts into the terminal ileum. This is occasionally observed normally, but in the tuberculous cases the spasm returns and roentgenographic study now reveals a spastic valve with barium in the ileum, which is slightly distended proximal to the valve (Fig. 3, A and B). The cecum is not distended.

Summary of Signs at Ileocecal Valve:

1. Increased valve visibility
2. Gaping valve with no evidence of obstruction
3. Delay or obstruction at valve
4. Regurgitation with obstruction

ROENTGEN SIGNS AT THE CECUM

The appearance of the cecum is likewise predicated upon the duration and severity of the lesion. The mucosal pattern may show a definite irregularity, but this may vary only slightly from the normal contiguous areas. There may be a hyperplastic prominence of the mucosa with a corresponding coarsening of the pattern (Fig. 7, A), or there may be a severe disruption of the pattern (Fig. 6). The shape of the cecum may be disturbed by spasm or organic changes (Figs. 1, 2, 3, 6). The sign described by Stierlin, which consists of a gap in the cecal shadow when the ileum and colon are filled, is occasionally seen, but it is neither sufficiently specific nor constant to be considered pathognomonic. The contour of the cecum may be somewhat stiffened. The mouse-eaten edge of ulcerative colitis may be observed (Fig. 5). The negative shadow within the cecum produced by the ileocecal valve is sometimes a prominent finding (Figs. 4 and 5). At other times a combination of spasm and organic disease results in a complete loss of the usual appearance (Fig. 2).

Summary of Signs at the Cecum:

1. Mucosal irregularities
2. Spasm and deformity of shape
3. Stierlin's sign
4. Contour changes
5. Negative shadow caused by ileocecal valve

INDIRECT ROENTGEN SIGNS

Appendix: The proximity of the appendix to this area makes its occasional involvement inevitable. Although a diseased appendix is notoriously difficult to diagnose by roentgenographic methods, nevertheless the findings are frequently suggestive. There is an irregularity of contour, and at times the actual niche of an ulcer may be seen (Fig. 7, B). At other times there is a gross and constant irregularity of the appendiceal outline (Figs. 1, 3, 7, B). Frequently the appendix may be shown to be fixed in an abnormal position.

Fig. 6. Case 6: H. S., a 23-year-old white male, died of pulmonary tuberculosis. His gastro-intestinal complaints included an episode of abdominal pain over McBurney's point. At autopsy, many small superficial ulcers were found scattered over the terminal ileum and cecum. Amyloid disease was present.

The roentgenogram made six hours after administration of barium by mouth shows gross disruption of the mucosal pattern. The ileum was not demonstrable. These findings would indicate the need of additional study.

Other Parts of the Colon and Ileum: Multiple lesions in the colon and ileum are the rule rather than the exception. Occasionally definite sites of disease may be demonstrated elsewhere in the colon (Fig. 7, C). These would tend to corroborate a diagnosis of ileocecal tuberculosis as differentiated from neoplasia or other disease.

While it is true that the number of lesions increases as the ileocecal valve is approached, many ulcers are found scattered along the jejunum and ileum. It is difficult to distinguish the resultant segmented and fragmented appearance of the bowel from a deficiency pattern, especially since so many of these patients actually do suffer

Fig. 7. Case 7: G. K., a 41-year-old white male with active pulmonary tuberculosis of at least a year's duration, complained, for six months before death, of abdominal cramps and diarrhea. Ileocecal tuberculosis and amyloid disease were found at autopsy. The terminal few centimeters of the ileum were ulcerated and narrowed, with a slight thickening of the walls. The cecum was retracted, moderately thickened, and ulcerated. The appendix was retrocecal and severely ulcerated. The colon showed several extensive girdling ulcers.

A. Post-evacuation barium enema study, showing narrowing of the terminal ileum and gross mucosal irregularity of the cecum and transverse colon.

B. Retrocecal ulcerated appendix. The barium collections correspond to ulcer craters verified at autopsy.

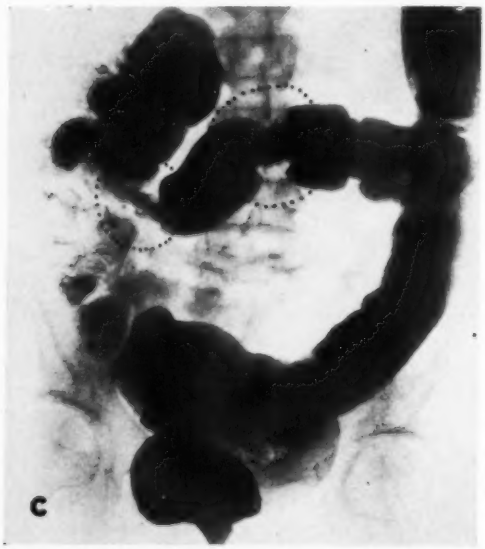

Fig. 7. Case 7: C. Multiple girdling ulcers in the right and central portions of the transverse colon.

from vitamin deficiency. Nevertheless, the associated ileocecal disease and the more intense reaction, as well as the constancy of some of the patterns, speak for small intestinal tuberculosis.

Appearance of Psoas Shadows: The right psoas shadow may be obliterated or very poorly visualized as compared to that on the left (Fig. 3, D). The explanation for this phenomenon is not certain. Several factors appear to contribute to it. A combination of local disease with tumefaction or regional lymphadenopathy plays an important part. The not infrequent association of amyloid disease results in an enlargement of the liver with downward displacement of the kidney over the psoas shadow.

Associated Liver and Spleen Enlargement: A surprising number of patients have an associated amyloid disease. The enlarged liver and spleen may frequently be

seen on the same film that demonstrates the ileocecal region. The other common cause for enlargement of these organs is a hematogenous tuberculous spread. In any case, an enlarged liver and spleen may be of indirect aid in the differential diagnosis. Enlargement of the liver alone may be confusing, since this might be due to metastases originating from a carcinoma of the cecum.

Disturbances of Intestinal Motility: Intestinal tuberculosis is usually associated with intestinal hypermotility. Barium may reach the cecum within one hour after oral ingestion. Hypermotility, however, is not invariable. In one patient barium did not appear in the cecum until the tenth hour.

DISCUSSION

The presence of active pulmonary tuberculosis in our patients simplified the diagnostic problem. The diagnosis was confirmed at autopsy in 4 of the 7 cases. In the other 3 the clinical and roentgen evidence was so direct as to allow little question. Roentgen appearance of these cases is sufficiently constant to permit an accurate diagnosis. In a general hospital the differential diagnosis would admittedly be more of a problem. Certain differentiation from a non-specific terminal ileitis would be extremely difficult. Nevertheless, in the presence of active tuberculosis elsewhere, and with scrutiny of all the direct and indirect roentgen signs, some attempt at differentiation might be justified.

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A Simple Method for Cardiac Measurements[1]

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THE MEASUREMENTS of the heart may be determined by the aid either of teleroentgenography or orthodiagraphy. The extensive use of teleroentgenograms for daily routine work, however, is beset with difficulties in private practice as well as in institutions because of lack of the necessary personnel and equipment. A major obstacle encountered in orthodiagraphy lies in the construction of the fluoroscope itself. In orthodiagraphy it is necessary to move the tube while the screen is held fixed over the patient's chest. Many fluoroscopes are not equipped with a detachable screen, the tube and screen moving together as a rigid unit.

Simple fluoroscopy, therefore, is often used to acquire information as to the size of the heart. The observer, in this instance, has to rely upon his personal impression, which is based upon his own experience. As no exact measurements are taken and no figures can be given, there is a very definite personal equation in this procedure.

It is felt that many would welcome a simple method that permits the taking of correct measurements of the heart in the course of fluoroscopy, thus substituting figures for impression. The following considerations, which comprise the basic principle of orthodiagraphy, aided in the conception of such a method, using the ordinary type of fluoroscope.

It must be assumed that the plane in which the tube moves, the diameter of the heart to be measured, and the screen are all parallel. If the tube is permitted to send only a small bundle of rays through a tiny opening in the shutter in front of it, these rays produce a small lighted area on the screen. If the tube is brought into the right position, a small part of the border of the heart shadow will be visible in the center of this lighted area. Let us suppose that the screen is held fixed in one position over the patient's chest and the exact spot indicating one border of the heart shadow is marked on the screen with a pencil; if the tube is then moved until the opposite border of the heart shadow is visible in the lighted area and this spot is marked on the screen, as before, the distance between the two points on the screen must equal the distance between the borders of the heart. Obviously, however, it is of no advantage to indicate these points on a screen which moves with the tube.

In order to apply this principle to the ordinary type of fluoroscope in which tube and screen form a rigid unit, the following method was devised. The patient holds in front of the chest a wooden rod graduated by means of lead rings encircling it. The distance between each two rings is 1 cm. For rapid orientation the center ring is made wider, the others are marked with lead numbers. The wider central ring is held over the middle of the sternum. With a small opening in the shutter, one focuses upon the point of the heart shadow farthest to the right. This point is visible between two lead marks of the rod or may coincide with a mark. The maximum distance of the right silhouette border from the midsternal line can be noted. The tube is then moved until the point of the heart shadow farthest to the left is in the center of the small lighted area. Again the distance from the midsternal line is read on the rod. The transverse diameter of the heart is the sum of these two distances.

The main difference between the procedure described here and orthodiagraphy itself consists in the fact that in the present method one reads the distances directly in centimeters during fluoroscopy (Fig. 1) instead of marking spots on a screen and

[1] From the Cardiac Service of the Hospital for Joint Diseases, New York. Accepted for publication in August 1944.

measuring the drawing later. In estimating the distance from the next mark on the rod, one will hardly make a mistake of more than 2 mm.

Obviously, it is extremely important that the rod be held strictly parallel to the plane in which the tube moves as well as to the screen. All distances would be distorted, and the results of the measurements would be incorrect, if the rod formed an angle to the plane in which the tube moves.

With this method one is able to measure the greatest distances both to the right and to the left of the mid-line, the transverse, the broad, and the long diameter of the heart. If the graduated rod is attached to a suitable base standing on the floor, one is independent of the co-operation of the patient. Then not only is the right position of the rod easily maintained, but it becomes possible, also, to take measurements in the oblique position.

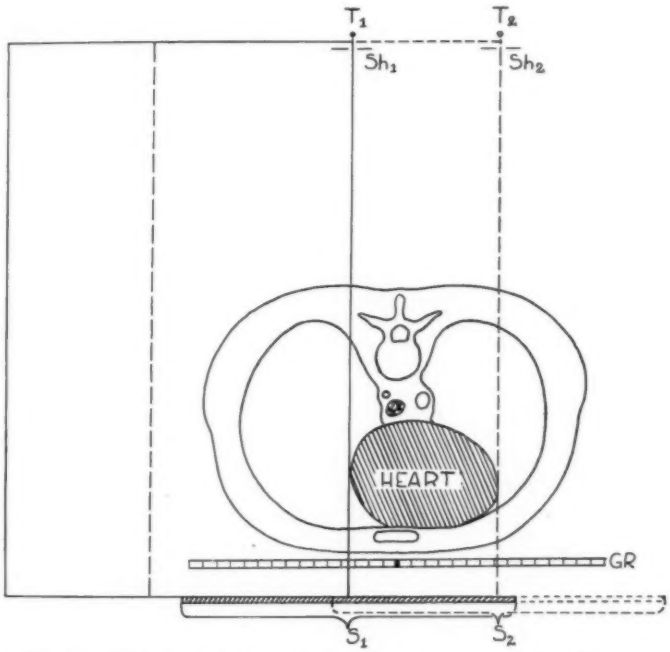

Fig. 1. Simple method of cardiac measurement. T_1 and T_2. X-ray tube in two different positions. Sh_1 and Sh_2. Shutter. *GR*. Graduated rod. S_1–S_2. Screen.

The position of the rod can be controlled by concentrating upon the lead marks. If one examines one mark after the other, moving the tube along the rod with a small opening in the shutter, all marks appear as lines if the rod is in the right position. Should the rod be in an incorrect position, the lead marks will be seen as circles. As the lead marks are more distinctly seen over the lung fields than over the heart shadow, it is recommended that they be counted, if necessary, from the end toward the center.

The idea of using a graduated scale for taking measurements of the body during fluoroscopy is older than orthodiagraphy itself. A year before orthodiagraphy was introduced into medicine, Donath (1899) suggested a device for measuring the distances between two bones in the body. He fixed a graduated scale in front of the tube. A metallic indicator was then connected with the tube, gliding with it over the scale. While taking the measurements, the tube was moved until the indicator corresponded with the margin of the first bone. Upon

changing to ordinary light, it was necessary to look at the scale in order to note the position of the indicator. With the light given off by the x-rays the margin of the second bone was determined as described above.

Apart from the fact that it now appears impracticable to attach a scale to the tube and inspect it at variable intervals during an examination, as well as the inconvenience of changing from x-ray light to ordinary light several times during fluoroscopy, this older method permitted only the measurements of horizontal distances. All these disadvantages can be overcome by the use of lead markings on an otherwise transparent rod which can be fixed, within easy reach for adjustment, between patient and screen. The readings are made immediately during fluoroscopy without any appreciable loss of time. In point of accuracy the readings appear to equal the results obtained with orthodiagraphy. The necessary aptitude in taking the measurements is easily acquired.

It is hoped that this simple device will be found to be a workable supplement to fluoroscopy of the heart, yielding more exact data concerning its diameters. It may prove to be desirable in daily routine work in clinics and offices for the recording of findings or as a means of comparing the findings of different observers or the findings in a given patient at varying intervals. These measurements may also have a didactic value not only for beginners who wish to compare their findings with accepted values, but also for more experienced workers who feel that they wish to control their impression in borderline cases and acquire more objective data.

NOTE: The author wishes to express his gratitude to Dr. V. de Beck for valuable assistance in writing this paper.

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Pes Planus: A Method of Mensuration[1]

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THE USE of roentgenograms for the detection of pes planus constitutes a simple, rapid, and precise method for the determination of the flatness of the longitudinal arch and the various degrees thereof.

Roentgenograms are taken with the foot in the lateral position, its external aspect against the film, and the x-ray beam directed from the inner to the outer aspect.

A tracing is made from the processed roentgenogram. It is not necessary, however, to trace the whole foot but rather to determine three points. To obtain these, a base line is drawn connecting the plantar surface of the head of the first metatarsal with that of the os calcis (Diagram 1). *A*

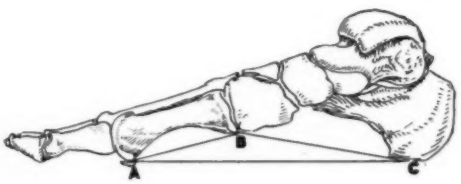

Diagram 1.

is the point of contact of the head of the first metatarsal with the base line, while *C* is the point of contact of the os calcis with the same line. *B* is the plantar surface of the base of the first metatarsal bone.

In patients whose feet are not absolutely flat, these three points will not be on a straight line. Euclidian plane geometry has taught us that through three points not lying on a straight line, one and only one circle can pass (1). To determine the radius of the circle passing through these three points, a line is drawn from *A* to *B*, and from *B* to *C*. Perpendicular bisectors to these lines are then constructed. The point of intersection of these perpendicular bisectors is the center of the circle passing through the three points, *A*, *B*, and *C* (Diagram 2).

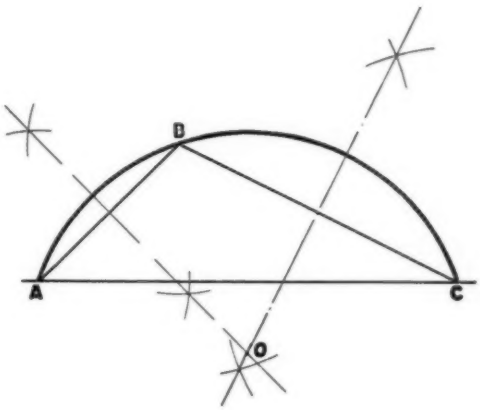

Diagram 2.

The distances *AO* (the radius of the circle) and *AC* (the chord) are then measured. The ratio *AO*/*AC* indicates the degree of flatness.

Ratio *AO*/*AC*	Interpretation
Up to 0.55	Pes cavus
0.56–0.80	Normal arch
0.81–0.90	1st degree pes planus
0.91–1.0	2nd degree pes planus
Greater than 1.0	3rd degree pes planus

The above numerical values were derived from the construction of theoretical arches and their mensuration. These values were verified with roentgenograms of actual cases.

These figures are confirmed on the basis of mathematical principles. The flatter the arch or arc *ABC*, the larger the radius of the circle passing through these points until an arc is reached where the points *ABC* are lying on a straight line and the radius of the circle is infinitely large.

The chord *AC* connecting the head of the first metatarsal with the plantar surface of the os calcis, varies linearly and directly with the size of the foot. The length of the

[1] Accepted for publication in June 1944.

radius is proportionate linearly and inversely to the degree of curvature of the arch. (The curvature of the circle equals the reciprocal of the radius. Granville, 2.) The ratio of the radius AO to the chord AC, as pointed out above, will produce a referable number by means of which various degrees of flatness of the longitudinal arch may be compared.

The points A, B, and C have been chosen because they are on the longitudinal arch. They are easily seen and constant on every film of the foot. With progression of the degree of flatness of the arch and changes in the size of the foot, these points too will vary.

The ratio AO to AC in a given foot remains constant even when roentgenograms are taken in positions varying from a true lateral to an oblique.

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Comparison of Physical and Biological Methods of Depth Dose Measurement[1]

CHARLES PACKARD, Ph.D.,[2] and FRANK M. EXNER, M.A.[3]

MANY radiologists have attempted to measure surface and depth doses under the actual conditions which they meet in practice, but the results have often been unsatisfactory because these measurements are difficult to make properly without special equipment and experience. That they are difficult even under the best conditions is shown by the considerable amount of disagreement in the data of qualified observers.

In view of this situation, it is now often recommended that the radiotherapist measure only free air doses and from these measurements calculate the desired tissue doses with the help of published ratios of surface and depth doses to air doses. The lack of complete and reliable compilations of such ratios, however, has been a handicap in following this procedure. To help fill this need it seemed to us desirable to make a comprehensive series of measurements of surface and depth dose ratios covering the whole range of deep therapy conditions. It was clearly essential, first, to make a thorough study of the possible reasons for the discrepancies between the results of previous observers, and to develop equipment and methods giving the greatest possible control over all the variables in the depth dose problem. A generator specially built for this purpose is described in the following paper, where a complete description of the beams of radiation used in the present experiments will also be found.

The task just outlined was undertaken as a long-term project about 1932 and was finished in 1942. Preparation of the results for publication, in this and the following paper, has been delayed by extraneous circumstances.

While the published measurements of tissue doses have been discordant, it is obvious that the distribution of any particular beam in a particular phantom is a definite and reproducible phenomenon. The discrepancies found in the literature of this subject are presumably due to (1) inadequate specification of the beam of radiation used; (2) use of different phantom materials and dimensions; (3) use of different dosimeters.

The present paper deals with the last of these points, namely, the selection of an appropriate measuring instrument for obtaining surface and depth dose ratios of reliable clinical significance.

In the past, both physical and biological methods have been used in making such measurements. Each method has its advantages and disadvantages. Ionization chambers permit rapid and precise measurements to be made. Such measurements, however, are subject to uncertainties connected with the geometrical characteristics and wave-length dependence of the chamber used. A biological test material, on the other hand, indicates dosage directly in terms of a biological effect. It has the further advantage that the disturbing effect of introducing an air cavity into the phantom may be avoided. But the method is laborious and, in comparison with physical measurements, is lacking in precision.

In the present paper, measurements by both methods are compared for radiations produced at approximately 200, 500, and 1,000 kv. No significant differences have been found between the *ratios* of tissue to air dose as given by the two methods. The ionization method was then employed to obtain an extensive series

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of surface and depth dose ratios covering the entire range of deep therapy conditions. The paper which follows this one describes these measurements together with an investigation of the conditions which should be fulfilled in order to obtain results which can be reproduced in another laboratory.

NOMENCLATURE

We shall follow the definitions of radiological terms given in the Glossary of Technical Bulletin No. 1 of the Radiological Society of North America (1). In this list the ratio of depth to skin dose is designated by the familiar term, percentage depth dose. *There seem, however, to be no accepted terms for two other important ratios: the ratio of depth dose to free air dose and the ratio of skin dose to free air dose.*

Instead of giving names to these ratios, we shall use the symbols D, D_0, and D_n for free air dose, skin dose, and depth dose (or intensity), respectively, as proposed by the Fifth International Congress of Radiology. We propose to represent the ratios by writing them explicitly D_0/D, D_n/D, and D_n/D_0, to be read as "surface to air ratio," etc. D_n/D_0, or depth to surface ratio, will be recognized as the familiar "percentage depth dose."

We shall express all dosage ratios as percentages, in conformity with established usage in the case of "percentage depth dose."

The practice of expressing dosage ratios in percentages leads to an ambiguity in speaking of errors or differences in these ratios. For example, if two D_n/D_0 are given as 20 per cent and 21 per cent, their absolute difference is 1 per cent, while their fractional difference is one part in twenty, or 5 per cent. *In the present paper, differences between ratios will be expressed in fractional form; 20.2 per cent will be said to depart from 20.0 per cent by a fractional difference of 1 per cent.*

The following abbreviations and symbols will be used:

f.s.d.: Focal skin distance
h.v.l.: Half-value layer
h: Homogeneity coefficient = ratio of second to first h.v.l.
D: Free air dose or intensity
D_0: Surface dose or intensity (at depth of 0 cm.)
D_n: Depth dose or intensity (at depth of n cm.)
D_e: Exit dose or intensity

METHOD OF MEASUREMENT

(*A*) *Physical:* The ionization chamber employed throughout this experiment was the widely used Victoreen condenser dosimeter, with a "25-r" chamber. *To assure electron equilibrium, caps of organic material up to 2 mm. thick were placed over the chamber during all free air and surface measurements at voltages above 300 kv.* The chamber and the method of submerging it in the water phantom are described in the following paper.

For voltages up to 200 kv. the dosimeter is calibrated in roentgens by the manufacturer, by a procedure approved by the National Bureau of Standards. To check the calibration, the instrument we used was returned to the factory at intervals. Between checks, three different chambers belonging to the electrometer were frequently intercompared. Comparisons were also made with other recently calibrated dosimeters. Over a period of years the calibrations of our three chambers (one 100 r and two 25 r) have remained constant within less than 1 per cent. Their relative indications, however, show differences up to 1 or 2 per cent, depending on the quality of radiation over the range up to 1,000 kv.

Readings were always corrected for temperature and pressure, the water in the phantom being kept at room temperature. For observations of surface intensity, the chamber was placed in the half submerged position.

(*B*) *Biological:* In the biological method, the dose to be measured is estimated from some clear quantitative reaction which follows exposure.

Of the many test objects used for biological measurement of x-rays, the eggs of

Drosophila have proved the most useful, because, unlike most other living material, their sensitivity can be kept remarkably constant year after year. This characteristic is not confined to a single stock of wild flies but is found in many stocks both in this country and abroad. Thus, in this laboratory, where the temperature has been constant at 20–22° C., a dose of 190 r kills, on the average, half the eggs in a sample. The same response is reported by Jüngling and Langendorff (3), who used the same technic as ours.

Data illustrating this constancy of response have already been published (4). From these and similar data collected over a period of years, a curve has been constructed showing the relation between roentgen doses and the survival rate of the eggs over a wide range of dosage (5). The slope and position of the survival curve plotted from data taken at 120 kv. are the same as the curves obtained in experiments with voltages ranging from 10 to 200 kv. (6, 7). Thus, this standard curve can be used not only to predict the survival rate which will follow any dose of radiation within these limits of voltage but, conversely, to determine from the survival rate what dose has been given. The validity of this method of measurement has been examined statistically (5) and the conclusion drawn that the roentgen dose estimated from the survival rate could be predicted (in the series examined) with a precision of the order of one part per hundred when the survival rate was about 50 per cent, and of the order of two parts per hundred when the survival rate was about 20 or 80 per cent.

This uniformity of response will not be found, however, if the temperature at which the eggs are prepared and exposed rises substantially above 20–22° C. This is shown in the following experiment. Eggs were collected from culture bottles incubated at 24–25° C. for two hours. They were then divided into two portions, one kept at 20° C. throughout the hour when they were being prepared for exposure, and the other at 27° C. In the exposure room, where they remained for about fifteen minutes, the temperature was 20° C. The data in Table I show the marked difference in the response of the two portions. The doses, measured by the dosimeter, are given in the first column; in the second appear the actual survival rates, and in the third, the expected rate according to the standard curve. It appears that when the eggs are kept cool, especially during the hour of preparation before exposure, their reaction does not differ significantly from that observed in previous tests under these conditions; but when the temperature is high during this period, the eggs undergo more cell divisions than do the others and are correspondingly less sensitive. In these tests their sensitivity was only 73 per cent of that shown by the sample kept at the lower temperature. In this instance, the 50 per cent survival dose is 260 r instead of 190 r. Sievert and Forssberg (8) report that in their experiments the half killing dose was 165 r, while den Hoed (10) found that under certain conditions it was 150 r and at another time 300 r. Evidently, then, those who use these eggs to measure dosage should maintain constant temperature conditions throughout all their experiments in order that their results may be consistent with each other. Even if this is not possible, measurements of surface and depth dose ratios, or ratios between the reaction of eggs in air and under some other condition, can still be carried out provided the exposures are made simultaneously, inasmuch as the ratios are not affected by changes in the sensitivity of the eggs.

TABLE I

Eggs Prepared at 20° C.			Eggs Prepared at 25° C.		
Dose in r	Per cent Alive	Per cent Expected	Dose in r	Per cent Alive	Per cent Expected
133	71.4	72.7	177	76.1	54.7
177	57.5	54.7	184	71.8	52.2
184	53.6	52.2	222	59.5	39.5

In recent experiments a disturbing factor not previously observed, has been the occasional aberrant behavior of eggs obtained

from perhaps a single culture bottle out of the six or eight usually employed in a test. Such eggs are far less sensitive than the rest, although they have been collected in the same way as the others. To correct this difficulty, the following procedure has been used in all recent experiments. The eggs obtained from each culture bottle are divided into approximately equal portions, which are placed on several pieces of black filter paper cut into some distinctive shape. In this way the records of the eggs from each bottle can be kept separate from all the others. One portion serves as a control, another is exposed in air, a third is irradiated at the surface of the phantom, and a fourth at some distance below the surface. Subsequently, the survival rates in each sample are obtained and the surface and depth dose ratios calculated independently for each culture bottle by a method to be described later. Although the absolute survival rates may at times differ among themselves considerably, the dosage ratios deduced from them agree very well.

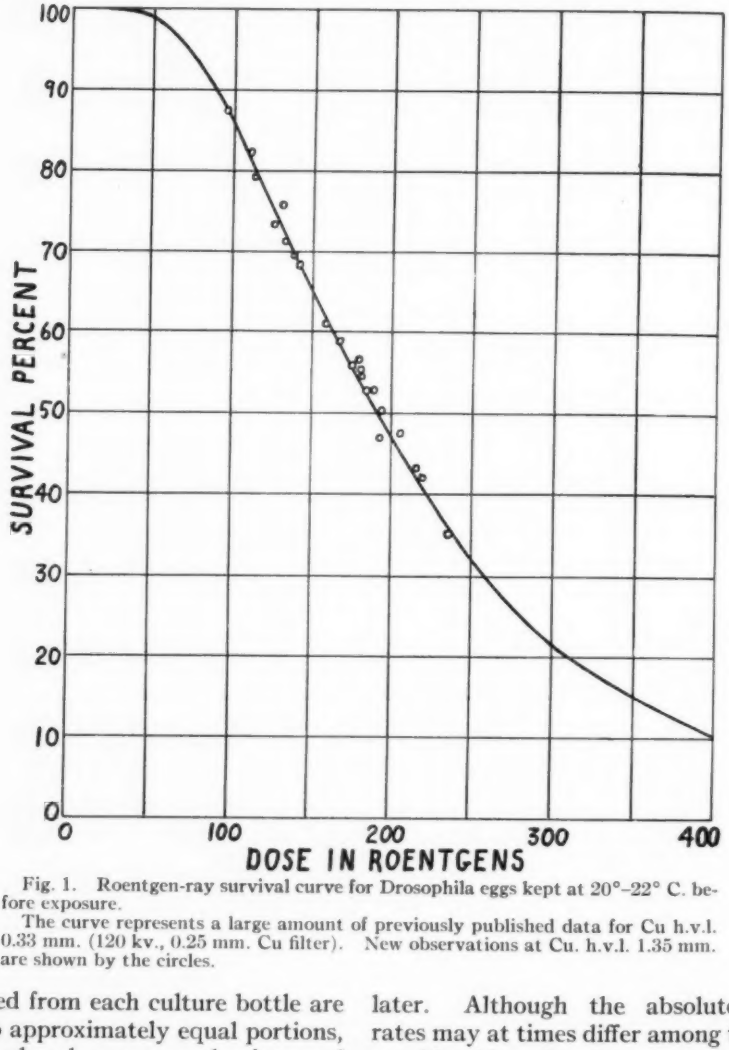

Fig. 1. Roentgen-ray survival curve for Drosophila eggs kept at 20°–22° C. before exposure.

The curve represents a large amount of previously published data for Cu h.v.l. 0.33 mm. (120 kv., 0.25 mm. Cu filter). New observations at Cu. h.v.l. 1.35 mm. are shown by the circles.

The procedure for obtaining the amount of exposure from the survival rate must now be further explained. It has been stated that the dose which the eggs have

received can be determined by finding on the curve (Fig. 1) the number of roentgens corresponding to the observed survival rate. At voltages below 200 kv., these doses will be expressed in standard roentgens. For example, a 50 per cent survival indicates a dose of 190 roentgens.

It is convenient to say that for radiations of any higher voltage, the dose which produces 50 per cent survival in the sample is 190 units, even though the dosimeter indicates a different number. These units have been called "biological roentgens" or "equivalent roentgens," convenient terms for expressing in biological units the amount of exposure directly in terms of biological effect. But these terms are open to objection. Instead, we shall use the term Drosophila unit.

After much preliminary work, the measurements to be reported in this paper were begun in 1936 and were continued, with many interruptions up to 1942. During this time each experimental condition, involving half-value layer, area, surface, and depth, was repeatedly tested. The figures given in the tables are averages of all tests made under the conditions mentioned. It is a matter of interest that the first and last measurements—separated by a space of nearly six years—of the surface to air ratio at a voltage of 900 kv. and 100 cm. area gave results which differed from each other by less than 1 per cent.

In all, upward of 500 separate experiments have been made, the average number of eggs in each being 1,200. Thus, well over half a million eggs have been exposed and counted in addition to the controls. In the latter, the hatching rate averaged 95 per cent, a somewhat lower value than that obtained in previous experiments.

COMPARISON OF BIOLOGICAL AND PHYSICAL MEASUREMENTS

(*A*) *Wave-length Effects:* In the preceding section it was stated that the Drosophila unit was found to be equivalent to the standard roentgen over a voltage range from 10 to 200 kv. The question whether this parallelism continues to higher voltages is complicated by the fact that the measurement of such radiations in roentgens has not been satisfactorily realized. In this situation it is convenient to use the indication of the Victoreen instrument as an arbitrary basis of dosage, expressing the readings in "Victoreen units."

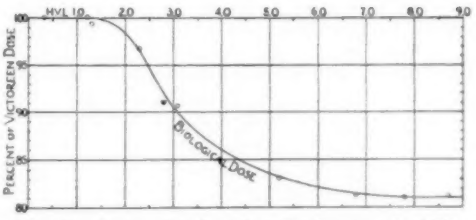

Fig. 2. Curve showing the effectiveness, in killing Drosophila eggs, of equal doses of roentgen rays as measured by a Victoreen dosimeter.

The effectiveness of doses of 100 Victoreen units is plotted against Cu h.v.l. (mm.).

A preliminary report on the relation between the Victoreen and the Drosophila units has been published (9). The results of a fuller study of this relation are shown in Figure 2. The falling curve indicates that the ratio of the Drosophila to the Victoreen dose rapidly diminishes between the half value of 2 to 5 mm. of copper, and for higher half values diminishes but little. Expressed in another way, the harder radiations when measured in Victoreen units appear less effective than the softer radiations.

Den Hoed (10) came to the same conclusion, finding that for equal doses measured by a Siemens dosimeter, the effectiveness of a beam of h.v.l. 5.9 mm. copper in killing Drosophila eggs is about 75 per cent of what it is when the beam has a h.v.l. of 1 mm. Evidence suggesting that this relation is not peculiar to Drosophila, but may be found elsewhere, appears in Stone's observation (12) that to give equal erythemas, the skin dose, including scatter, of 1,000-kv. radiation as measured by the Victoreen must be increased over that of 200-kv. radiation by about 25 per cent. This relation, however, is not universal. Special types of test material such as

TABLE II: TO ILLUSTRATE THE METHOD OF CALCULATING SURFACE/AIR AND DEPTH/SURFACE RATIOS, AND THE AMOUNT OF VARIATION IN SENSITIVITY IN SAMPLES OF EGGS DERIVED FROM DIFFERENT BOTTLES EXPOSED AT THE SAME TIME

(Copper h.v.l. 5.2 mm.; area 100 cm.²; f.s.d. 70.7 cm. Intensity measured in Victoreen units/min.)

Air Dose, 9 min.		Surface Dose, 9 min.			10-cm. Depth Dose, 18 min.		
Per cent Alive	Drosophila Units	Per cent Alive	Drosophila Units	D_0/D	Per cent Alive	Drosophila Units	D_n/D_0
37.1	230	29.2	263	114.3	32.7	247	46.7
59.1	166	49.3	192	115.7	53.0	182	47.8

those in which x-ray-induced gene mutations may be observed, show a very different relation between h.v.l. and dose (11).

(*B*) *Geometrical Effects:* Some of the geometrical complications inherent in the application of thimble chambers to the measurement of surface to air ratios have been discussed by Quimby, Marinelli, and Farrow (18). The ratio of depth (chamber fully submerged) to surface (chamber half submerged) doses involves additional geometrical complications. As is stated by these authors, it is difficult to evaluate the importance of all these possible sources of error, which may be too small to be significant or may tend to cancel out. To test the validity of ratios measured with a thimble chamber, it is best to compare them with values obtained by some other method which avoids these errors without introducing new ones.

The small size of Drosophila eggs (0.2 × 0.5 mm.) makes it possible to avoid these geometrical errors. It is true that during depth exposures the eggs are kept in a bakelite holder (see following section) which has an air cavity 3 mm. in thickness, a condition which might have a disturbing effect. To test this point, eggs were exposed in a gelatine jelly container with a cavity just deep enough to hold them. To avoid possible damage to the eggs from lack of oxygen, they were ventilated by a stream of air introduced through a rubber tube about 1 mm. in diameter. The results of depth measurements with this container agreed with those made with the bakelite holder. The test was made with a beam having a copper h.v.l. of 0.3 mm. We conclude, therefore, that the air cavity had no disturbing effect. This test was made before our high-voltage equipment was set up and was not repeated with hard radiation.

PHANTOM MEASUREMENTS TECHNIC

A description of the water phantom is given in the following paper. Free air and surface measurements were made at a focal distance of 70.7 cm. *At higher voltages both eggs and chamber were covered with sufficient organic material to ensure secondary electron equilibrium.* The thimble chamber, protected by a close-fitting thin rubber cover, could be placed at any desired position in the phantom. The beams of radiation were filtered and diaphragmed in such a way as to contain a minimum of secondary x-rays. The physical measurement and specification of the beams used are described in full in the following paper.

A typical biological experiment is performed in the following way. Several thousand eggs are collected from culture bottles incubated for two hours at about 25° C. During the next hour the eggs are prepared for exposure by transferring about 200 of them, by means of a camel's-hair brush, to each of a number of slips of filter paper about 1.5 × 1.5 cm. in size. As mentioned before, the eggs from each culture bottle are placed on slips cut into some distinctive shape so that when they are counted the results can be calculated separately.

The eggs are usually exposed in three positions simultaneously, that is, in air without scatter, at the surface, and at a depth in the phantom. This procedure is made possible because the generator at our disposal has several ports. The samples irradiated in air are placed on a sheet

TABLE III: SURFACE/AIR RATIOS DETERMINED BY THE BIOLOGICAL METHOD WITH PHYSICAL VALUES FOR COMPARISON

h.v.l. mm. Cu	10 cm.²		50 cm.²		100 cm.²		200 cm.²		400 cm.²	
	Biological	Physical	Biological	Physical	Biological	Physical	Biological	Physical	Biological	Physical
1.35	114.6 ± 0.44	112.0	125.7 ± 0.83	124.0	132.5 ± 0.71	132.0	...	...	143.2 ± 0.72	144.1
5.2	107.2 ± 0.14	106.8	115.0 ± 0.31	113.2	116.1 ± 0.42	117.7	120.2 ± 0.21	121.5	123.6 ± 0.99	124.5
6.9	...	...	...	...	112.4	112.5	...	...	...	...
8.7	103.8 ± 0.43	104.0	106.3 ± 0.45	105.9	107.1 ± 0.45	107.7	...	...	111.2 ± 0.44	112.2

TABLE IV: DEPTH/SURFACE RATIOS DETERMINED BY THE BIOLOGICAL METHOD

Area →	10 cm.²	50 cm.²	100 cm.²	200 cm.²	400 cm.²
Copper h.v.l. 1.35 mm.; f.s.d. 70 cm.					
Depth, cm.					
1	...	...	...	...	99.8 ± 0.68
5	...	...	66.4 ± 0.82	...	77.3 ± 0.49
10	21.5 ± 0.48	29.1 ± 0.63	35.8 ± 0.52	...	46.0 ± 0.66
Copper h.v.l. 5.2 mm.; f.s.d. 70 cm.					
1	...	...	98.9 ± 0.81	...	...
3	...	...	86.0 ± 0.53	...	...
5	...	65.1 ± 0.38	69.3 ± 0.59	74.3 ± 1.47	77.0 ± 0.52
10	26.3 ± 0.51	35.6 ± 0.25	41.0 ± 0.36	45.0 ± 0.33	50.5 ± 0.42
15	...	...	24.8 ± 0.61	...	...
20	...	...	12.4 ± 0.38	...	...
Copper h.v.l. 8.7 mm.; f.s.d. 70 cm.					
1	...	...	103.0	...	...
5	...	...	74.5	...	...
10	35.2 ± 1.59	42.1 ± 0.38	46.0 ± 0.63	...	52.7 ± 0.77
15	...	...	27.7 ± 0.72	...	...

of gauze held vertically in a wooden frame in front of one of the side ports. The phantom is placed below the bottom port. In making surface dose exposures, the slips carrying the eggs are supported on a raft made of varnished gauze or cellophane attached to a light wooden hoop. *For voltages above 250 kv., the eggs exposed in air and at the surface are covered with sufficient celluloid for electron equilibrium.* For exposures at a depth, the eggs are placed in a holder made of a sheet of bakelite 0.3 mm. in thickness, in which square holes about 2 cm. on a side have been cut. These are sealed on the under side with cellophane and beeswax. The slips of paper with their eggs are then placed in these compartments, which are slightly moistened so that the slips will stick to the bottom. A second sheet of cellophane is sealed over them, making water-tight compartments in which the eggs can stay several hours without suffering from lack of oxygen. Actually they are seldom sealed up for more than thirty minutes.

When the holder is placed in the water phantom, it is inverted so that the eggs lie next to its upper surface, from which the depth is measured. It is held accurately in place at the desired depth by cleats fastened to the walls of the phantom. Before each exposure the depth of the eggs below the surface is carefully checked, and the phantom is accurately centered under the bottom port of the generator. The phantom and holder are shown in Figure 4 of the following paper.

The beam is so adjusted that at the greatest depth the intensity will be well above 5 r/min. Before each irradiation the equality of intensity at the side and bottom port positions is tested with the ionization chamber. Often two or even three depth exposures are made at the same time, together with the surface dose measurement. The exposure for all of the eggs thus arranged begins at the same time and is interrupted, after an appropriate length of

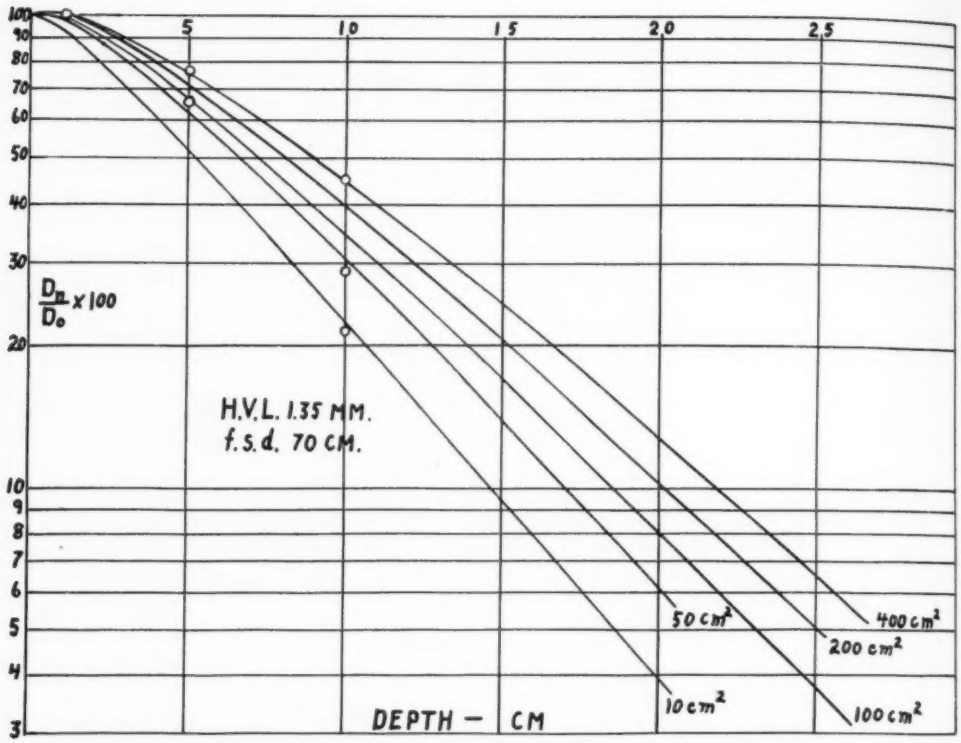

Fig. 3. Comparison of depth to surface ratios (percentage depth doses) measured with Drosophila eggs and with a Victoreen dosimeter. H.v.l. 1.35 mm., f.s.d. 70 cm.
The curves represent Victoreen measurements described in the following paper. The Drosophila measurements are shown by circles.

exposure, long enough to remove the samples at the surface and in air. Irradiation is then resumed for the eggs at the depths and is continued until all have received the desired dose.

The doses, measured in Drosophila units, at these various positions are calculated from the survival rates, and from these the D_0/D and D_n/D_0 ratios are calculated. As mentioned before, these measurements are calculated separately for the eggs derived from each culture bottle, so that variations in sensitiveness do not affect the ratios.

The method of making these calculations is illustrated in Table II, which includes, also, an example of the fact that occasional changes in the sensitiveness of eggs from a single bottle do not affect the ratios. The horizontal series of figures are measurements and calculations from individual culture bottles. In the first vertical column of each section are the percentages of eggs surviving after exposure to the indicated dose of Victoreen roentgens. In the second column are given the number of Dorsophila units corresponding to these percentages. The third column of sections 2 and 3 give the D_0/D and D_n/D_0 ratios, respectively. It will be seen that, although the actual hatching rates and the number of corresponding Drosophila units in each column differ greatly, the ratios do not. Indeed, the agreement is excellent.

RESULTS

Most of the experiments were made with beams having half value layers of 1.35, 5.2, and 8.7 mm. of copper. The results are given in Tables III and IV. Each figure is an average of many separate tests made under similar experimental conditions, often separated by months or even years. The amount of variation between indi-

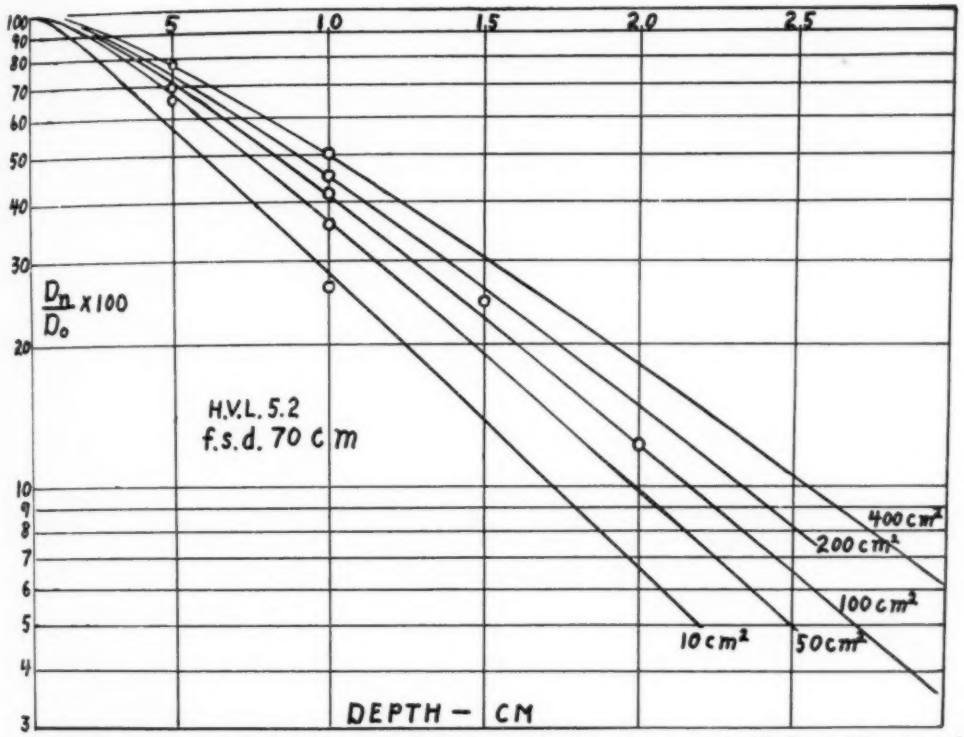

Fig. 4. Comparison of depth to surface ratios (percentage depth doses) measured with Drosophila eggs and with a Victoreen dosimeter. H.v.l. 5.2 mm., f.s.d. 70 cm.
The curves represent Victoreen measurements described in the following paper. The Drosophila measurements are shown by circles.

vidual tests may be inferred from the probable errors of the means, which are calculated for each. In addition, other observations were made at intermediate half values. All the D_n/D_0 ratios are shown in Figures 3, 4, and 5, where they may be compared with the results of dosimeter measurements shown by the curves. The data for the latter are given in the subsequent paper. The differences between the D_0/D and D_n/D_0 ratios obtained by the two methods are small and within the limits of experimental error. The conclusion is, therefore, that the biological and physical methods of measurement of phantom ratios give results which are in complete agreement.

DISCUSSION

An extensive series of biological measurements in which Drosophila eggs were employed has been made by Langendorff, Graf, and Graf (13). With a beam having a half value of 0.95 they found D_n/D_0 ratios, for areas of 50 and 400 sq. cm., to be definitely greater than those obtained with the dosimeter. Henshaw (2), on the other hand, who also used these eggs as test material, reports that under radiation produced at 165 and 650 kv. these ratios are lower than his dosimeter values.

The close correspondence which we find between the biological and dosimeter ratios is worthy of discussion, for, *a priori*, one might suppose that they should not agree. For example, when a beam having an h.v.l. of 5.0 mm. Cu is scattered in a phantom, one might imagine that its h.v.l. could be reduced to 3.0 mm. Cu. Its biological effectiveness, as compared with the free air beam, will thereby be increased by about 9 per cent, as shown

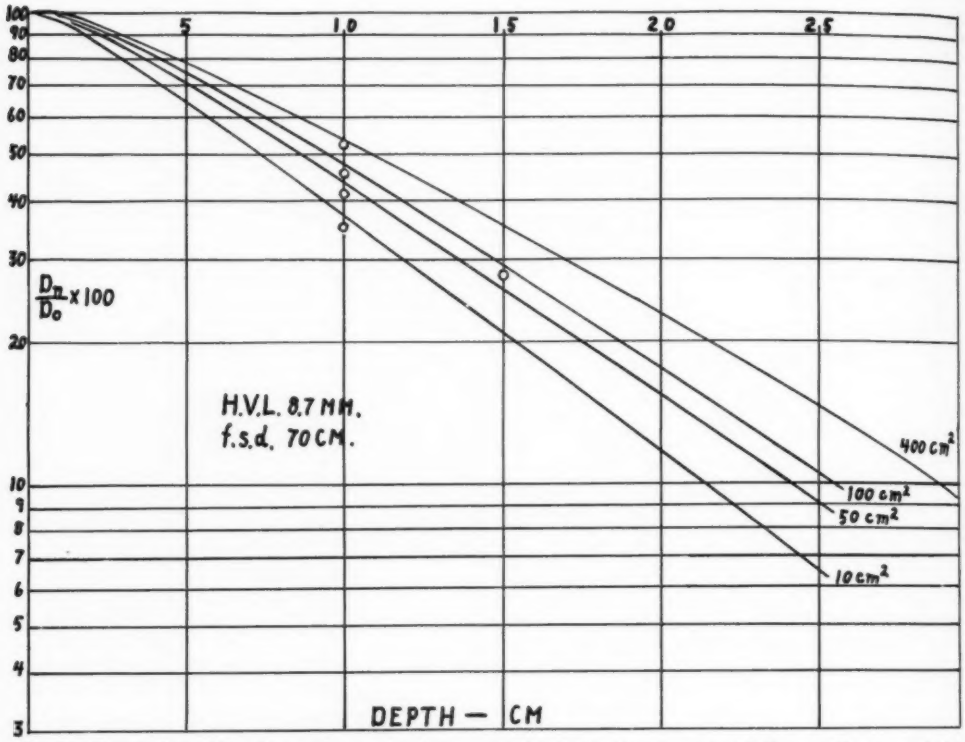

Fig. 5. Comparison of depth to surface ratios (percentage depth doses) measured with Drosophila eggs and with a Victoreen dosimeter. H.v.l. 8.7 mm., f.s.d. 70 cm.
The curves represent Victoreen measurements described in the following paper. The Drosophila measurements are shown by circles.

in Figure 2. The result of this would be that the D_n/D_0 ratio would become greater than that shown by the dosimeter. That no such difference has been found may mean simply that the amount of softening due to scatter is too small to produce an effect which we can measure.

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Measurements of Surface and Depth Dose Ratios from 70 to 1,000 Kv.[1]

FRANK M. EXNER, M.A.,[2] and CHARLES PACKARD, Ph.D.[3]

IN GIVING deep x-ray therapy it is necessary to determine the doses to which the skin and underlying tissues are exposed. Some of the steps to be taken when tissue doses must be determined accurately may be listed as follows:

1. Measure the free air dose at the point which is to be the center of the field on the skin.
2. From known ratios of tissue doses to the free air dose, for the conditions of the exposure, determine the doses at the center of the field for the entrance and exit skin surfaces, and for any desired depths.
3. Find the lateral distribution of tissue dose over the field at the tumor level. For this purpose, a suitable isodose chart may be used (1, 15), together with a knowledge of the lateral distribution of intensity in the primary beam.
4. From the size of the focal spot and the position of the defining diaphragm, find the width of the penumbra inside and outside the edge of the geometrical field at any important levels.
5. Allow for the effect of bone, gas, or fat in the exposed region.
6. If the ratio of length to width of field is greater than about 2, apply the proper correction (2).
7. In case of cross-fire, add the superposed doses.
8. For very hard radiations consider the possible effects of incomplete secondary electron equilibrium (3).
9. For excitation voltages above approximately 250 kv., take account of any available information on the biological efficiency of the unit in which the dosage is measured (such as a particular thimble chamber unit). (Preceding paper, and 4.)

The present paper is concerned with providing a comprehensive, reliable, and convenient set of dosage ratios to be used in the second step of the procedure just outlined.

In order that all deep therapy radiations, from the softest to the hardest, might be measured under similar experimental conditions, a special generator was built, and much time was spent in working out methods for precisely controlling all the experimental conditions. A particular effort was made to select conditions for the measurements such that the results might be reproduced, if desired, by any other experienced observer in a well equipped laboratory.

Since the experiments were completed, their preparation for publication has been delayed by pressure of other duties. To avoid further delay, we are presenting our own results with almost no reference to earlier literature containing valuable discussions of questions dealt with in the present paper. Instead, two recent publications containing bibliographies and compilations of dosage ratios (5, 14) and a few still more recent reports of new measurements (6, 7, 16, 17) are cited.

Methods were devised for presenting all depth dose ratios by means of a few unfamiliar but very simple charts, which permit interpolation for any set of exposure conditions. The way in which the charts are obtained is explained in detail; and at the end of the paper summarized directions for their use are given. These directions are accompanied by a numerical example and are intended to be self-explanatory, so that the charts can be used, if desired, without reference to the rest of the paper.

The paper is divided into sections as follows:

Part 1. Description of apparatus.
Part 2. Analysis of conditions to which deep therapy beams should conform in order that depth dose measurements may be reproduced from one laboratory to another.
Part 3. Specification of beams to be employed in the following depth dose experiments.

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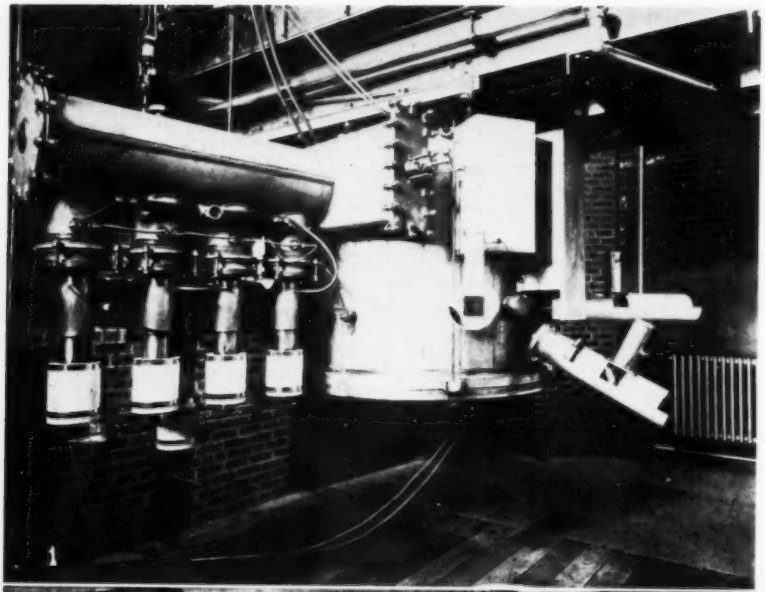


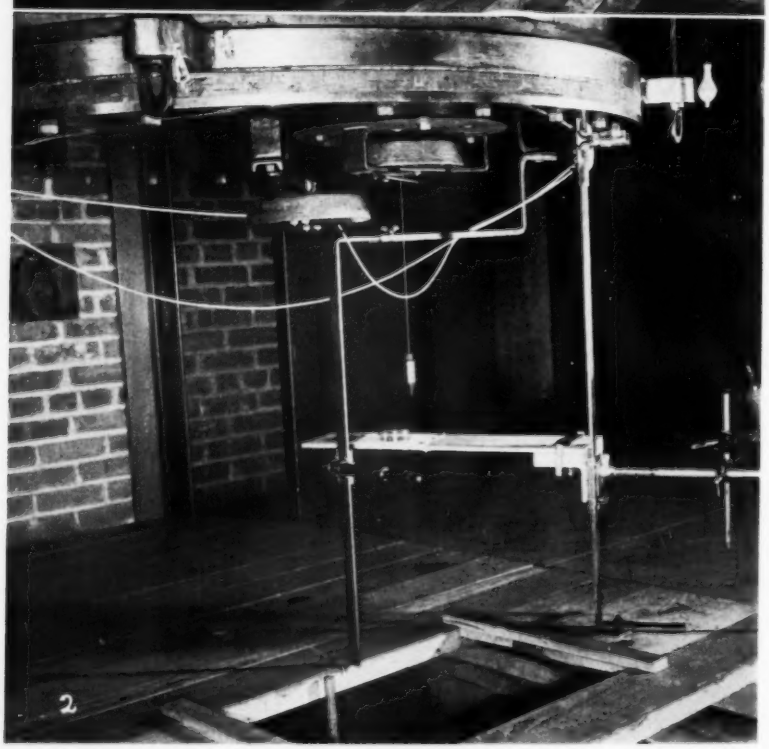


Fig. 1. Vacuum chamber of Sloan x-ray generator. Three of four side ports fitted for deep therapy can be seen at the right; vacuum pumps at the left. The sides of the vacuum tank are covered with 2 inches of lead, with 3 additional inches on the side toward the control room. In a copper shield above the vacuum chamber are mounted two continuously pumped oscillator tubes capable of supplying peaks of over 100 kilowatts at 6 megacycles to the primary of the resonance transformer in the vacuum chamber.

Fig. 2. Bottom port, showing diaphragm, shutter and arrangements for free air exposures.

Part 4. Measurement of surface and depth dose ratios in water, at center of field, for copper half-value layers from 0.1 to 8.7 mm.; surface areas 10 to 400 cm.^{2}; depths from 0 to 30 cm.; focal skin distances 50, 70, and 140 cm. A few measurements in presdwood and meat are described for comparison with water. A few exit doses were measured.

Part 5. Representation of measured surface and depth ratios by graphical methods, permitting convenient interpolation. Simple method for calculating exit doses. *Summarized directions for using dosage charts.*

[As explained in the preceding paper, we represent free air, surface, depth and exit doses or intensities by the symbols D, D_0, D_n, and D_e, respectively.]

PART 1. DESCRIPTION OF APPARATUS

A. Generator: In order to study depth dose problems over the whole range of deep therapy conditions, it was desirable to have a generator capable of operating at voltages from about 70 to 1,000 kv. and having very small inherent filtration. The biological part of the work (see preceding paper) required large outputs at all voltages. It was necessary to have the output steady and reproducible, with instantaneous on-and-off control. A small focal spot, flexibility of diaphragming arrangements, and freedom from scattered radiation were also desired.

Such a generator of the Sloan (9) radio-frequency resonance transformer type was built for this purpose. In this apparatus a tungsten target hung at the free end of a water-cooled quarter-wave resonant coil in a metal vacuum chamber, shown in Figure 1. A biased filament emitted electrons to the target over a greater or less portion of the positive half cycle of target potential, depending on the amount of bias potential. Close control of emission was given by fine adjustment of bias. Cut-off bias applied by a double-throw switch provided instantaneous on-and-off control.

The vacuum chamber had a bottom port (Fig. 2) which was used for most of the experimental work. The inherent filtration at this port was only 0.6 mm. aluminum. The arrangement of the port in relation to the target is shown in Figure 3.

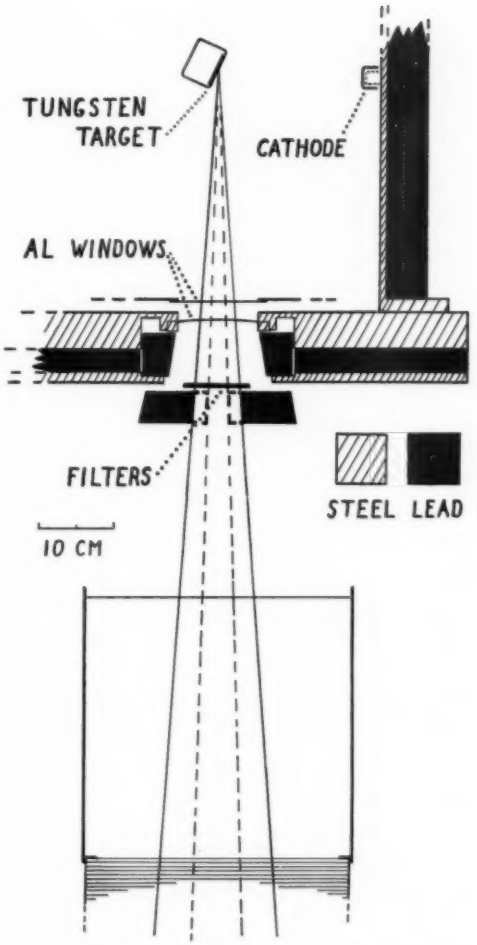


Fig. 3. Scale diagram showing arrangement of target, port, and phantom for measurements at 70 cm. f.s.d. The tungsten target is set in a water-cooled copper block shown in outline. The combined thickness of the two aluminum windows is 0.6 mm. A beam covering a field of 100 cm.^{2} is shown in solid lines. The broken lines represent a 2.5 × 3.5 cm. aperture used in obtaining transmission curves. The phantom measures 35 × 35 × 35 cm. It has a presdwood bottom and sits on a pile of presdwood sheets about 20 cm. thick.

A number of side ports were available for control purposes.

The geometrical arrangement was such as to minimize off-focus and secondary radiation from inside the vacuum chamber. "Cold emission" x-radiation was negligible in amount in all experiments. With the hardest beam of radiation listed in Table II, cold emission measured at 70 cm.

f.s.d. and 400-cm.² field was only 0.2 per cent of the total intensity.[4]

The average emission current was read on calibrated milliammeters on the control board.

As an output monitor, a galvanometer at the control desk could be switched either to a large ionization chamber at a side port or to a calibrating network. Since output per milliampere is a function of effective voltage, the galvanometer and milliammeter together allowed any desired voltage setting to be held constant and reproduced at a later time.

The projected area of the focal spot for the vertical beam of x-rays was roughly 1.5 × 1.5 cm. The position of the focus was accurately determined from vertical and horizontal pin-hole beams.

B. Ionization Chamber: The measurements described in this paper were made with a Victoreen condenser dosimeter. The same 25-r chamber was used throughout, *with additional wall material for the harder radiations.* Other chambers were used for monitoring and for special tests.

The 25-r chamber has a bakelite wall about 0.6 mm. thick, with a special inside coating. The wall is cylindrical with rounded end. The outside diameter and length are 12.5 and 23 mm. The central electrode is aluminum, about 1 mm. in diameter.

A second similar chamber and a smaller 100-r chamber were used as monitors at a side port in some of the work. As stated in the preceding paper, the calibration of these chambers has remained constant within 1 per cent over a period of years.

Caps of organic material (paper, lucite) were placed over the chambers when working at copper h.v.l.'s. of 7.4 and 8.7 mm. With the hardest rays the increase obtained by adding 1.5 mm. lucite to the chamber in a narrow beam was between 2 and 3 per cent. Readings under water were the same with or without the cap.

[4] When the apparatus was first put into operation, an objectionable amount of cold emission was obtained at higher voltages. A new high-voltage coil with slightly wider spacing between turns eliminated this trouble.

The holder for immersing the chamber and its condenser stem was made of a short piece of copper tube. At one end a rubber finger cot 0.05 mm. thick was attached, the other end being closed with a rubber stopper. The rubber cot was held closely against the chamber wall by wrapping with a few turns of silk thread each time the chamber was inserted. A little graphite powder shaken into the cot allowed the chamber to slip in and out easily.

It was found that when the butt end of the condenser is exposed to rays hard enough to penetrate the brass cap, there is a considerable amount of ionization. To avoid such an effect from scattered rays in the phantom, a lead shield was placed around the butt end of the holder.

No serious attempt was made to compare the Victoreen 25-r chamber with other chambers. To see whether the size of the chamber was sufficient to affect appreciably measurements near the surface, a single test was made in which the D_n/D_0 ratio at 1 cm. depth (200 sq. cm., 70 cm. f.s.d., 1.35 mm. h.v.l.) was measured with the Victoreen 25-r chamber, a Victoreen 100-r chamber (10 mm. diameter), and a graphite chamber (4.5 mm. diameter). The measurements agreed within experimental error. (D_n/D_0 was 0.997 by the 25-r chamber, 1.003 by the 100-r chamber, 1.00 by the graphite chamber.)

A wave length calibration of a Victoreen chamber given by Eddy (10), together with the manufacturer's claims, indicates that the readings of the chamber are independent of wave length from 2.0 mm. down to 0.5 mm. Cu h.v.l.

In the preceding paper it is shown that the effectiveness of x-rays in killing Drosophila eggs decreases by about 20 per cent as the h.v.l. is increased from 2 to 9 mm. of copper, if the radiation is measured with a Victoreen chamber. It was found, however, that *ratios* of surface or depth to free air measurements for three different h.v.l.'s were the same whether measured with the Victoreen chamber or with the eggs. Apparently the change of wave length by

scattering in the phantom is not great enough to change the biological effectiveness of the Victoreen unit of dose by an appreciable amount. It is concluded that the Victoreen chamber is suitable for depth dose measurements at all deep therapy h.v.l.'s.

C. Phantom: Water was chosen for the phantom material. A few comparative measurements on lean meat, fat, and "presdwood" are described at the end of Part 4 (p. 386).

The phantom was a cubical container 35 × 35 × 35 cm., shown in Figure 4. The sides were of zinc-coated steel sheet; the bottom was a sheet of masonite presdwood (untempered) 6 mm. thick, coated on the inside with asphalt. To provide sufficient back-scattering material for measurements near the bottom, the phantom was placed on a pile of presdwood sheets 20 cm. or more thick. Since the contribution of the presdwood to the measurements was small, the difference from water may be neglected.

To test whether the width of the phantom was sufficient, a presdwood phantom of the same dimensions was employed, with a beam of Cu h.v.l. 1.3 mm.; f.s.d. 70.7 cm.; field size 400 cm.^{2} These conditions were chosen for maximum importance of side-scattering. Adding 7 cm. of presdwood to three sides of the phantom increased the intensity at a depth of 14 cm. by only 0.5 per cent.

The phantom was nearly filled with water, which was kept at room temperature to avoid disturbance of the chamber readings. Care was taken to prevent cooling of the chamber by evaporation from the wet surface of its rubber cover.

The mineral content of the water, including chlorine, as given by the city water department is equivalent in photoelectric absorption to 0.002 mm. of copper in the whole depth of the phantom.

Measurements at zero depth were made with the chamber half immersed. Simple but accurate positioning devices were used by which the chamber in its holder could be placed quickly and easily at any desired position in the phantom. Depth settings were accurate to less than 0.5 mm. Focal distance and beam alignment were carefully maintained. To make measurements of exit doses, a special shallow water phantom was used. This phantom is described in Part 4 (p. 385).

Fig. 4. Water phantom with chamber holder in surface position. A bakelite and cellophane holder used for exposing flies' eggs in the phantom is also shown (see preceding paper). The wooden frame supporting the phantom on the carriage was replaced by a pile of presdwood to give additional back-scattering.

PART 2. ANALYSIS OF CONDITIONS FOR REPRODUCIBILITY OF SURFACE AND DEPTH DOSE MEASUREMENTS

As stated in the preceding paper, the disagreements found between phantom measurements published by different observers may be attributed to: (1) use of different dosimeters; (2) use of phantoms of different materials and dimensions; (3) inadequate specification of beams of radiation.

The aim of the present investigation was

TABLE I: RELATION OF INTENSITY MEASURED AT 70.7 CM. f.s.d. TO FIELD SIZE FOR THE RADIATIONS EMPLOYED IN DEPTH DOSE MEASUREMENTS

(The field was defined by a single diaphragm as shown in Figure 3. The 18-cm.² beam was used in the measurements for transmission curves.)

Area (cm.²) →	18	50	100	200	400
Cu h.v.l.					
0.11 mm.	1.00	1.007	1.013	1.022	1.036
1.35	1.00	1.011	1.015	1.026	1.039
5.2	1.00	1.015	1.022	1.032	1.058
8.7	1.00	1.023	1.035	1.072	1.095

to obtain phantom ratios which could be accurately reproduced by any experienced observer in another laboratory. To this end, a large water phantom and a widely available commercial dosimeter were used. It then remained to consider what beam conditions should be adopted and specified.

The characteristics of an actual beam of radiation may be discussed in relation to a beam of monochromatic rays from an ideal point source. To facilitate comparison with other workers, it is desirable to employ beams which approach the ideal as closely as practical considerations allow. The departure of actual beams from the ideal will be discussed under two headings: Geometrical Characteristics and Wave Length Composition.

A. *Geometrical Characteristics of Beams*

1. Penumbra: Due to the finite size of the focal spot, an actual beam is bounded by a penumbra. This should not affect the dose at the center of the field except in an extreme case where the greater average distance of the rays from the axis of the beam might appreciably reduce the amount of scatter at the center. For the narrowest beams used for phantom measurements in the present investigation, the defining diaphragm was placed only 5 cm. above the water surface to avoid possible penumbra effect.

2. Off-focus Radiation: Besides rays from the focal spot, the beam may contain "stem radiation," together with secondary rays from parts inside the tube, from edges of diaphragms, and from filters. These non-focal rays result in a progressive increase in the free air intensity measurement as the beam width is increased by a diaphragm placed as in Figure 3. This increase is shown for several beams in Table I. Special tests using a dummy diaphragm and movable filter indicated that all the sources mentioned above contributed appreciably to the off-focus radiation. The large increases with field size seen in the hardest beams are chiefly due to scatter from the thick filters used.

Tests with the chamber placed outside the penumbra and covered on top with a thick piece of lead showed that floor scatter was negligible in all the beams described in the paper. The concrete floor, laid directly on solid earth, was 175 cm. below the target.

3. Divergence Index: Due to the presence of non-focal rays, as described above, the free air intensity will not follow the inverse-square law for distance from the focus, but will decrease more rapidly as a result of rays coming from less than the focal distance (as from the filter). In other words, the beam is on the average diverging more rapidly than the focal rays. To describe the average divergence of a composite beam at any focal distance—f cm.—we use a "divergence index" which we define as:

$$\text{d.i.} = \frac{I_{f+25}\,(\text{meas.})}{I_{f+25}\,(\text{calc.})} = \frac{I_{f+25}}{I_f \cdot f^2/(f+25)^2}$$

where I_f and I_{f+25} represent *free air* intensities measured at f cm. and $f + 25$ cm., respectively. For a beam obeying inverse-square law, the divergence index is unity. A value less than unity expresses the intensity at $f + 25$ cm. as a fraction of the value calculated by the inverse-square law. The distance 25 cm. is chosen to correspond to the depth to which phantom measurements are commonly carried.[5]

For the beams employed in the present investigation, the divergence index was found to vary from unity to about 0.96, de-

[5] An alternative way of observing the relative intensity of focal and non-focal rays is by the data tabulated in Table I. The excess above unity shown in Table I is somewhat larger than the deficiency of the divergence index below unity for the same f.s.d.

pending chiefly on field size and focal distance. The largest field at highest voltage and thick filter shows a somewhat lower value. Instead of trying to correct all depth dose curves to unity divergence index we have adopted a divergence index of 0.98 as normal. Variations of ±2 per cent (1.0 to 0.96) will not significantly affect depth dose measurements from a clinical standpoint, although it will be shown in Part 4 that the effects of such differences are in some cases easily measurable.

Special tests were made which seem to indicate that, within the limits imposed by keeping the divergence index near unity and avoiding excessive penumbra, the positions of diaphragms and filters may be varied at will without significantly affecting the relation of phantom intensities to field area.

4. Lateral Intensity Distribution: Due to the non-uniform directional emission of x-rays, as well as to absorption in the target and tube wall, and to the greater distances to the edges of the field compared to the center, there may be a considerable variation in intensity about the axis of the beam. Such lack of uniformity would be expected to be greatest at high voltages (11). The departures of the intensity in our widest 1,000-kv. beam from the value at the center are shown in Figure 5. Since the intensity at the edge of the field affects only a small portion of the scatter received at the center, it is estimated that phantom measurements at the center of the field will not be in error by more than 1 or 2 per cent as a result of the distribution shown in Figure 5, which represents our worst case.

5. Diaphragm Transmission: If the diaphragms are too thin, the additional radiation transmitted outside the aperture will be scattered in the phantom into the center of the field. By inspection of the curves showing D_n/D_0 ratios in relation to field size (Figs. 9*a–k*), it appears that in the worst cases (narrow beams, great depths) the measurements will not be in error by more than the order of 1 per cent if the diaphragm transmits not more than 0.002 of the filtered radiation intensity. At higher voltages this requires lead diaphragms up to 4 or 5 cm. in thickness.

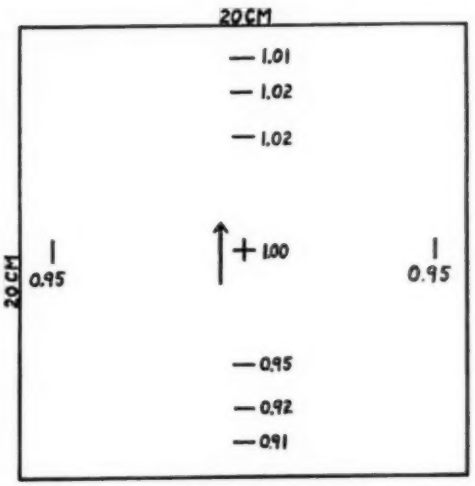
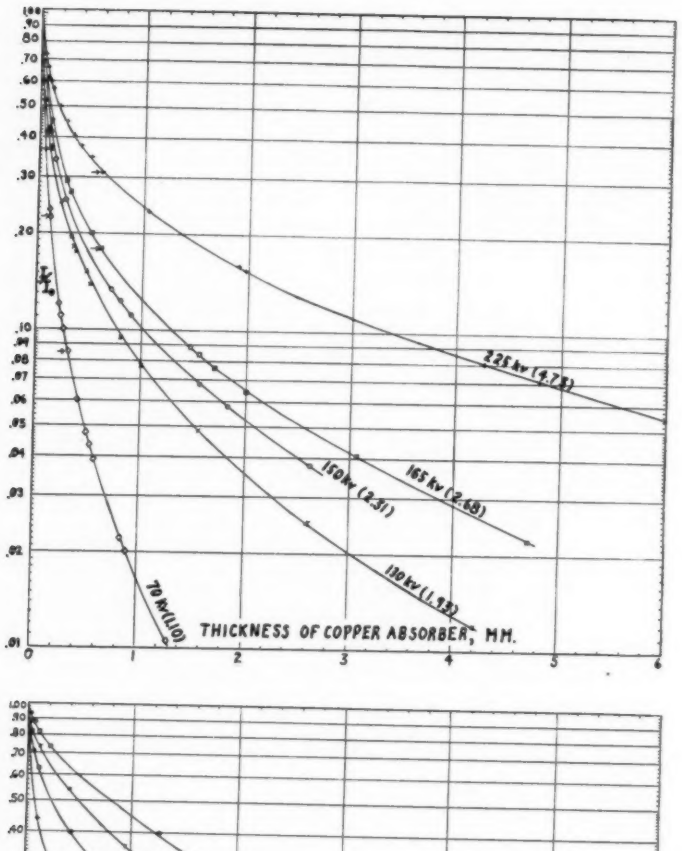


Fig. 5. Intensity distribution over 20 × 20 cm. field in air 70.7 cm. below focal spot, 8.7 mm. Cu h.v.l. The direction of the electron stream is shown by the arrow.

B. Wave Length Composition of Beams

1. Half-Value Layer and Homogeneity Coefficient: The wave length composition of a beam of x-rays depends on excitation voltage (peak value and wave form), filtration (inherent and external), direction from electron stream, and target material. It is usually difficult to reproduce all these factors in different laboratories, at least for the higher voltages. It is better for the purpose of the present discussion to specify quality in terms of narrow beam transmission curves in suitable absorbing materials. The same ionization chamber was used for the absorption measurements as for the rest of the experiment.

The narrow beam transmission curve for a monochromatic radiation plots as a straight line on semi-logarithmic paper. The h.v.l. obtained from such a curve specifies the beam quality completely (between absorption jumps). A heterogeneous beam gives a logarithmic transmission curve which is concave upward. The ratio of second to first h.v.l. obtained from such a curve is greater than unity the



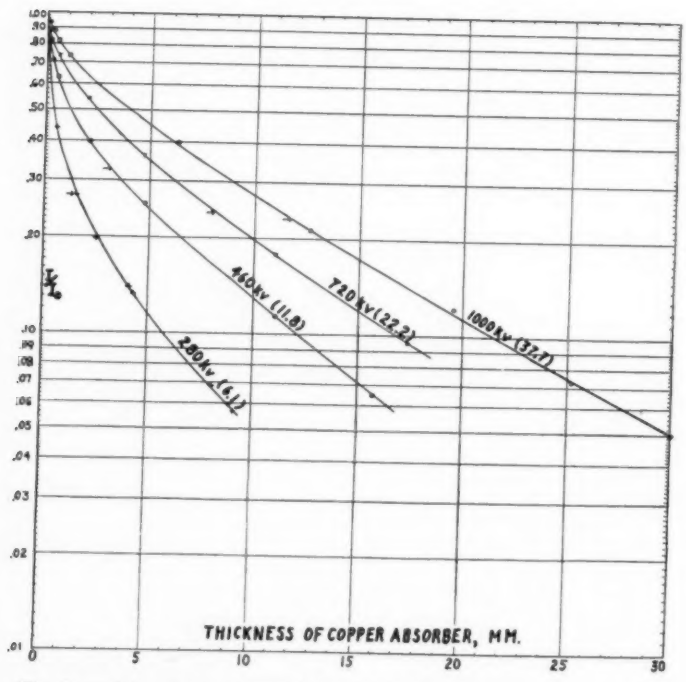


Fig. 6*a* and *b*. Copper transmission curves for radiations with no initial filtration except the window of the tube (0.6 mm. Al). [*Legend cont. on opposite page.*]

more heterogeneous the beam. This ratio has been called the homogeneity coefficient, denoted by h.

2. Homogeneity Coefficient in Water: The representation of depth dose ratios would be greatly complicated by the introduction of more than one variable to indicate quality. It seems reasonable to suppose that a heterogeneous radiation whose narrow beam transmission curve *in water* is not appreciably curved will not differ significantly from a monochromatic beam of the same h.v.l. in its wide beam distribution in a phantom. For beams filtered so as to satisfy this condition, the h.v.l. in any convenient material should be a sufficient specification of quality.

Copper is well suited for h.v.l. measurements over the whole range of deep therapy wave lengths. Even for the hardest radiations now in use, there seems little need to change to lead, since the variation of absorption with wave length in tissue is never more rapid than in copper.

Transmission curves in water and copper were obtained for all the radiations used in the present study, as described in Part 3. For the two hardest beams lead h.v.l.'s were also measured.

An experiment with an inhomogeneous beam is described in Part 4 and discussed in Part 5. The results of this test, shown in Fig. 9*b*, indicate that a rather slight curvature of the water transmission curve has an appreciable effect on the depth dose curves.

3. Characteristic Radiation: The h.v.l.'s obtained from narrow beam measurements are used to describe the corresponding wide beams used for phantom measurements. The forward scattering from filters, diaphragms, etc., will not differ greatly in wave length from the focal radiation. Characteristic radiation, however, might cause error if present in appreciable amount. Tests for characteristic radiation in the beams used for depth measurements are described in Part 3.

PART 3. SPECIFICATION OF QUALITY OF BEAMS TO BE EMPLOYED IN THE FOLLOWING DEPTH DOSE EXPERIMENTS

In accordance with the discussion in Section B of Part 2, narrow beam transmission curves will be used to describe the radiations to be used in Part 4. In all narrow beam transmission measurements a diaphragm of 2.5 × 3.5 cm. was used in the position shown in Figure 3. The filters and metal absorbers were placed on top of the diaphragm. Water absorbers were placed directly under the diaphragm. To hold the water, a piece of brass tubing 5 cm. in diameter, closed at one end with 1 mm. celluloid sheet, was used. To avoid meniscus error, the water level was measured from the top, using a blunt metal point coated with vaseline.

The 25-r chamber, described in Part 1, was placed at a sufficient focal distance, usually 100 or 122 cm., to receive the transmitted beam without an appreciable amount of scatter from the absorbers. Background was usually negligible, but in one or two cases a small correction was made at the lower end of the curve.

The beams of radiation used for the depth dose measurements were produced with voltages of widely different wave form. At the lowest voltage the cathode was unbiased, while the higher voltages were well biased. The exact relation of minimum to peak voltage in any case is not known.

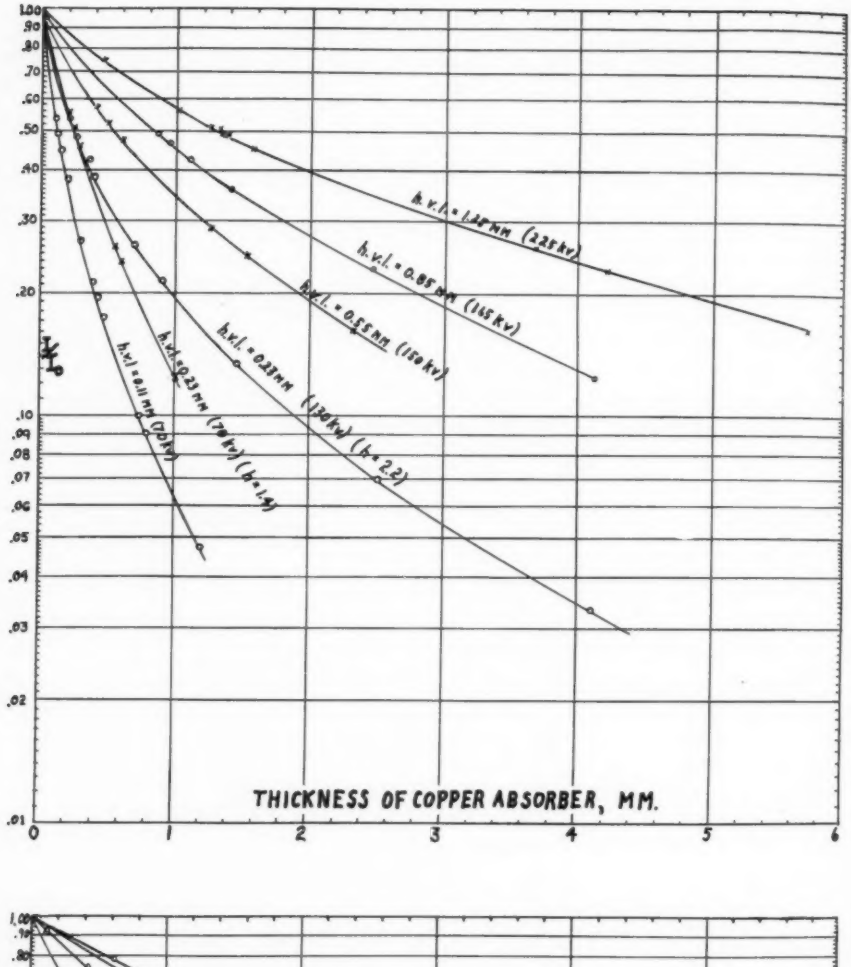
To specify quality as completely as possible, the following procedure was employed. For each voltage setting, a copper transmission curve was obtained for the radiation emerging from the 0.6 mm. Al window of the vacuum chamber. These curves are shown in Figures 6*a* and *b*, together with the outputs in r/min. per milli-

Legend for 6a and b cont.

The outputs (I_0) in r/min. per milliampere at 100 cm. from the target are shown in parentheses beside each curve for the initial beams coming from the window.

The voltages specified are "equivalent constant potentials" estimated from the curves as explained in the text.

An intensity equal to that of the filtered beam used for depth dose measurements is indicated on each curve by an arrow. In those cases where copper filtration was used, the curve below the arrow is reproduced in Figs. 7*a* and *b*.



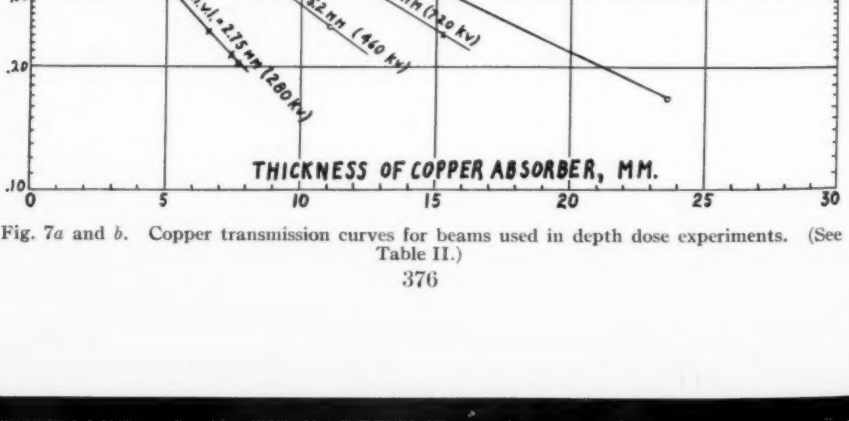


Fig. 7*a* and *b*. Copper transmission curves for beams used in depth dose experiments. (See Table II.)

TABLE II: DATA ON DEPTH DOSE BEAMS

Copper, h.v.l.	h	Water, h.v.l.	h	Pb, h.v.l.	Filter, mm.	Milli-amperes	Output*	Equivalent Constant Potential
0.11 mm.	1.8	2.2 cm.	1.1	...	0.075 Cu + 1.05 Al	16.4	0.25	70 kv.
0.23	1.4	2.7	1.1	...	0.305 Cu	16.4	0.093	70
0.23	2.2	2.7	1.1	...	0.11 Cu	30.0	0.71	130
0.55	1.8	3.2	1.1	...	0.305 Cu	30.0	0.54	150
0.85	1.7	3.7	1.0+	...	0.60 Cu	30.0	0.48	165
1.35	1.8	4.1	1.0+	...	0.60 Cu	15.2	1.48	225
2.75	1.4	...	...	...	1.51 Cu	20.2	1.73	280
5.2	1.1	5.3	1.0	...	1.03 Sn + 1.1 Cu	4.1	3.83	460
7.4	1.0	6.0	1.0	1.73 mm.	1.02 Pb + 1.53 Sn + 0.25 Cu	4.1	5.4	720
8.7	1.1	6.8	1.0	2.95	2.1 Pb + 3.15 Cu	2.6	8.7	1000

* Output is given in r per minute per milliampere at 100 cm. from the focus.

ampere at 100 cm. from the focus with only the inherent filtration (0.6 mm. Al).

From the unfiltered outputs and the transmission curves, outputs and h.v.l.'s can be found for any desired copper filtration for comparison with published values. From such comparisons with published data obtained with constant potential excitation, equivalent constant potentials have been estimated for our radiations and are used to identify the different voltage waves represented by the curves. For the higher voltages, the comparison was based on outputs for 0.5 mm. Cu given by Kaye and Binks (12) and for 2.5 mm. Cu by Bouwers and van der Tuuk (13). The lower voltage estimates are based mainly on h.v.l. comparisons. No attempt was made to determine how closely the estimated equivalent constant potential would apply over the whole transmission curve.

With each of these voltage waves and a suitable filter, a beam for a depth dose experiment was obtained (two beams were obtained from the lowest voltage with different filters). Copper transmission curves for the filtered beams are shown in Figures 7*a* and *b*. In those cases where a copper filter was used, the curves for the filtered beams are taken from the corresponding portions of the curves in Figures 6*a* and *b*. Otherwise, separate measurements were made.

Transmission curves for water are shown in Figure 8. Because of technical difficulties, the water transmission measurements are less precise than those with copper. But it is found that the water transmission curves are substantially straight except for the very soft beams. To test the effect of non-homogeneity on phantom ratios, two beams of h.v.l. 0.23 mm. Cu, but different homogeneity coefficients, were used. D_n/D_0 ratios for these beams are plotted in Figure 9*b* and are discussed in Part 4.

For the two hardest beams, h.v.l.'s in lead were obtained. In Table II is assembled information about the beams used in the depth dose experiments.

A number of tests for the presence of characteristic radiation in the depth dose beams will now be described. To test for K radiation from a copper filter, intensity measurements were made with the copper filter placed first below and then above a 1-mm. Al filter. If the ratio of the first to the second reading is greater than unity, the increase is due to K radiation from the copper. Tests were made with four of the depth dose beams described in Table II, and similar tests for Pb K and L radiation were made with the hardest beam:

1. Cu h.v.l. 8.7 mm., field 400 cm.^{2}, filter 2.1 mm. Pb + 3.15 mm. Cu + 1.0 mm. Al, 28 cm. above chamber (Fig. 3). Ratio (Al up/Al down) is 1.001. No detectable amount of K radiation.

2. Cu h.v.l. 1.35 mm., field 400 cm.^{2}, filter 0.6 mm. Cu + 1.0 mm. Al, 28 cm. above chamber. Ratio (Al up/Al down) 1.001. No detectable amount of K radiation.

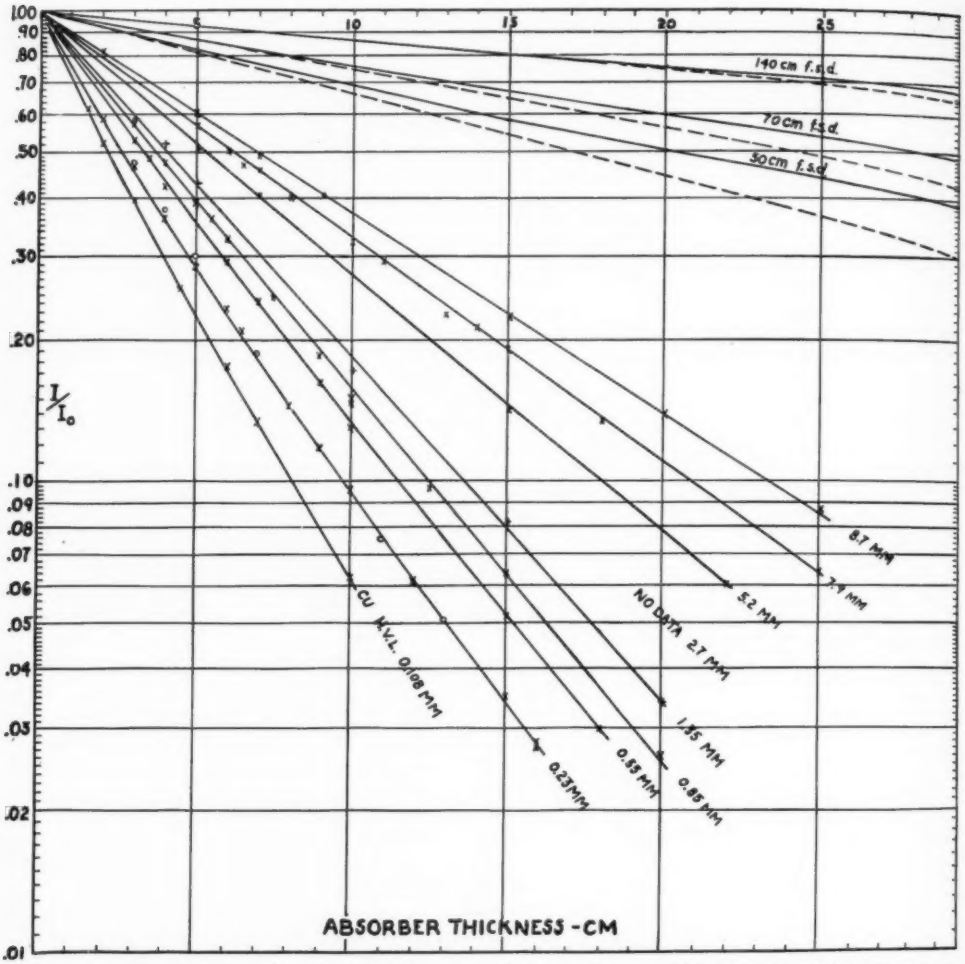


Fig. 8. Transmission curves in water for the beams used in depth dose experiments. (See Table II.) Copper h.v.l.'s are indicated for each curve. The measurements for 0.23 mm. Cu h.v.l. with h = 0.22 and 0.14 are shown by crosses and circles, respectively.

At the top of the chart, inverse-square law curves and their exponential approximations are shown by solid and broken lines, respectively.

3. Cu h.v.l. 0.11 mm., field 400 cm.², filter 0.075 mm. Cu + 1.0 mm. Al, 28 cm. above chamber. Ratio (Al up/Al down) 1.02. Since 2 per cent of Cu K radiation is thus shown to be present, the Al filter was used with this beam.

4. Cu h.v.l. 0.23 mm., h = 1.4, field 100 cm.², filter 0.31 mm. Cu + 1 mm. Al, *5 cm. above chamber.* The excess intensity measured with the filters in this position compared to a narrow beam with filters at 28 cm. was 11 per cent with Al up and 5 per cent with Al down. Hence characteristic radiation accounts for about half of the excess radiation in the wide beam. No Al filter was used in the depth dose measurements with this beam, but the air, surface, and 1 cm. depth intensities were corrected for the characteristic radiation present, which would be absorbed by a thin layer of water.

5. A test for Pb K radiation was made as follows: Cu h.v.l. 8.7 mm., f.s.d. 70.7 cm., field 100 cm.,² filters 2.1 mm. Pb + 3.1 mm. Cu, 2 cm. above chamber. The excess obtained over the intensity for a narrow beam with the filters 28 cm. above the chamber was 25 per cent for Cu down and 21 per cent for Cu up. The increase for Cu down cannot be explained as Cu K radiation, which would not be appreciable with such a hard primary beam. Rather the scattering from the lead is diminished, compared to copper, by photoelectric absorption of scattered

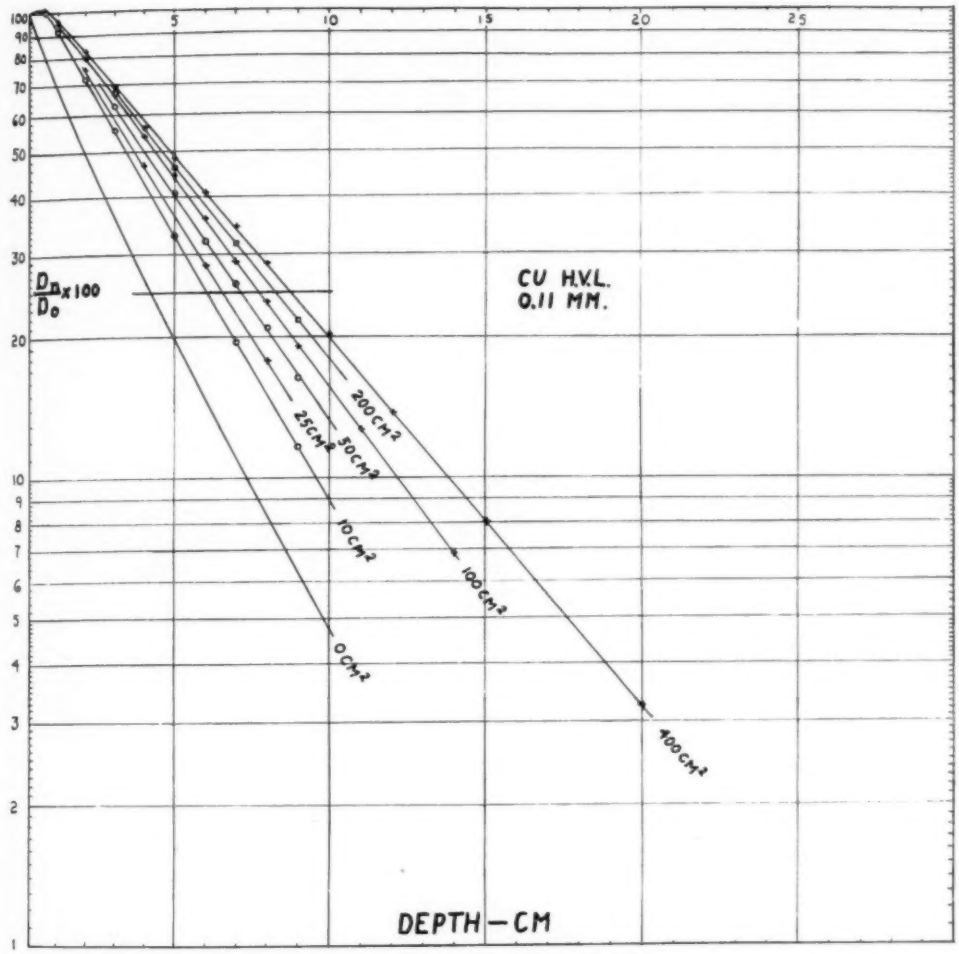


Fig. 9*a*. D_n/D_0 ratios, 70.7 cm. f.s.d.

rays. The copper filter was used, not to absorb characteristic radiation, but to help filter the primary wave lengths longer than the Pb K absorption limit.

A test for Pb L radiation was made with the same voltage and geometry as in the Pb K test. Filters 2.1 mm. Pb + 1 mm. Al. Ratio (Al up/Al down) was 0.995, giving no evidence of Pb L radiation.

PART 4. SURFACE AND DEPTH DOSE MEASUREMENTS

With the apparatus described in Part 1, surface and depth measurements were made for the beams described in Part 3. A few exit dose measurements were also made. The phantom measurements were made at focal-skin distances of 50, 70.7, and 141.1 cm. These distances were chosen for convenience in testing inverse-square law relations.

Figure 3 shows the geometrical arrangement for measurements at 70.7 cm. Square fields were used in all cases. Lead diaphragms about 4 cm. thick were employed. The edges were tapered to match, approximately, the divergence of the beams. Field sizes 10, 25, 49, 97, 190, and 385 cm.^{2} were used. In the charts which follow, these fields are designated by the nearest round numbers for simplicity of presentation.

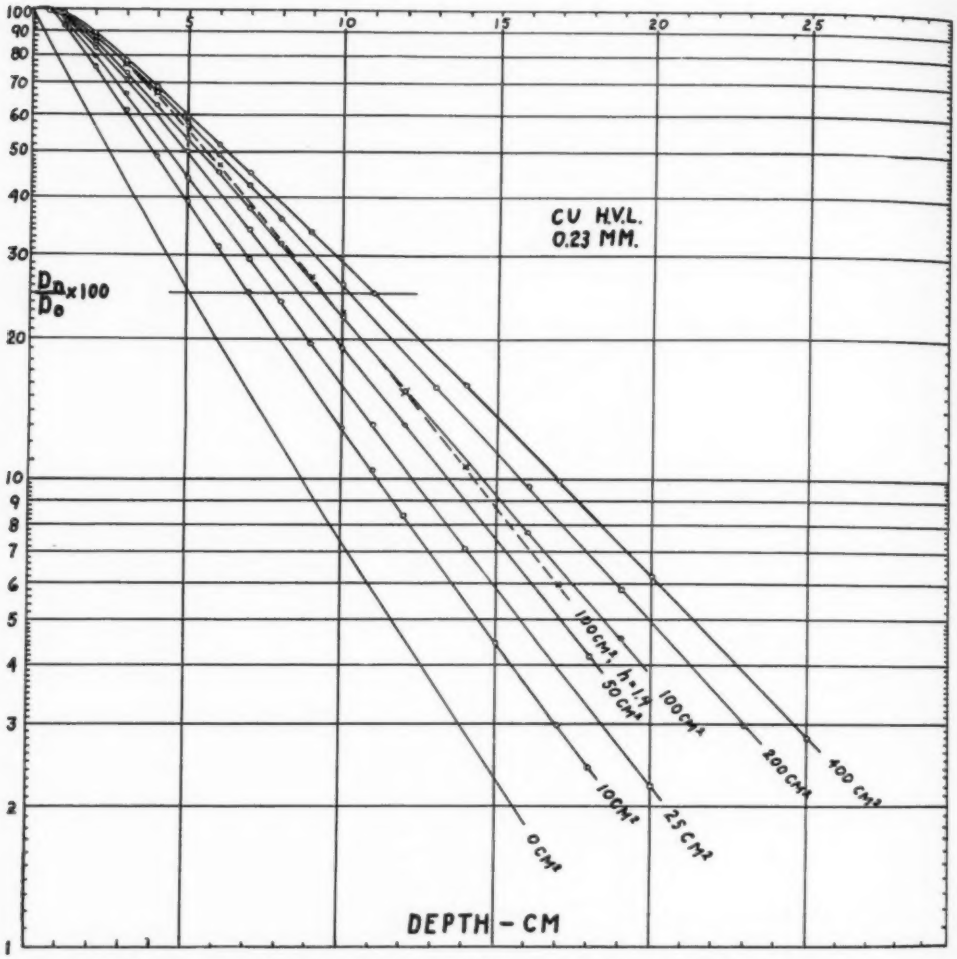


Fig. 9*b*. D_n/D_0 ratios, 70.7 cm. f.s.d. Solid lines: h = 2.2. Broken lines: h = 1.4.

For measurements at 141.4 cm., the defining diaphragm was placed from 30 to 55 cm. above the surface. The filter and a supplementary diaphragm were placed as in Figure 3. For the measurements at 50 cm. f.s.d., special filters and diaphragms were made which could be fitted immediately below the aluminum window of the vacuum chamber. For the 10-cm.^{2} beam at all f.s.d.'s the defining diaphragm was placed 5 cm. above the surface to avoid having an excessive portion of the total radiation in the penumbra zone.

From the free air and phantom intensity measurements, surface to air and depth to surface ratios were calculated for each beam and field size. The D_0/D ratios are shown in Figure 12 and D_n/D_0 ratios in Figures 9*a–k*.

The detailed procedures employed in order to keep all conditions constant during a series of measurements will not be described, as different methods might be more appropriate in another laboratory. Because of the number and complexity of the experimental conditions to be checked and kept under control, it was found that the better part of a day was usually spent getting ready to start a series of measurements. Most of the observations were

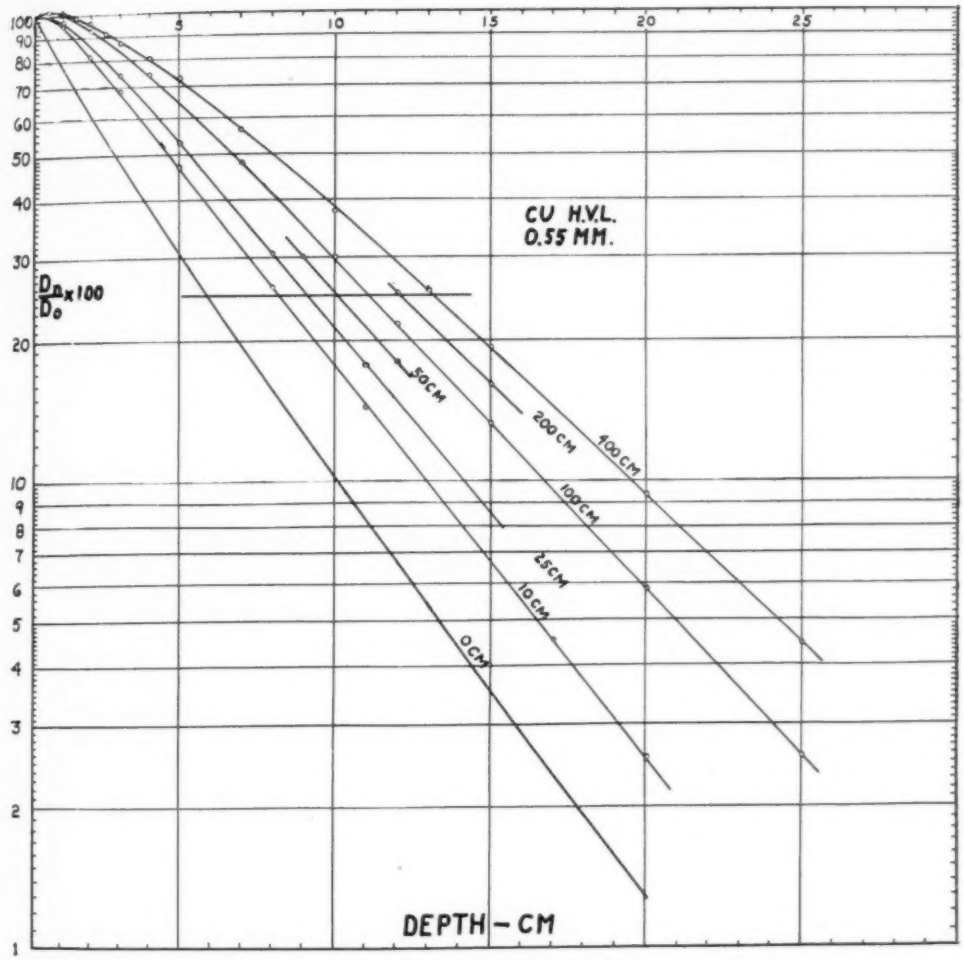


Fig. 9*c*. D_n/D_0 ratios, 70.7 cm. f.s.d.

therefore made in continuous runs of twenty-four to thirty-six hours.

In some experiments a series of free air and phantom measurements was made while the output was held constant with the help of a large ionization chamber and galvanometer. (See description of generator in Part 1.) The free air measurement could be held constant for hours or even days with an average deviation of 0.5 per cent or less.

In other experiments each measurement at the bottom port was accompanied by a monitor measurement with another Victoreen chamber at a side port. In order to have monitor readings matching in precision the measurements at low intensities in the phantom, three different focal distances at the side port were calibrated in relation to the bottom port. This method is convenient, in that accurate timing of the exposures is not required.

Several readings were taken for each free air and surface intensity. Most of the depth intensities were observed only once. The precision of the dosage measurements can be judged from the closeness with which the plotted points lie along the D_n/D_0 curves in Figures 9*a*–*k*. In most cases where a point deviated more than 1

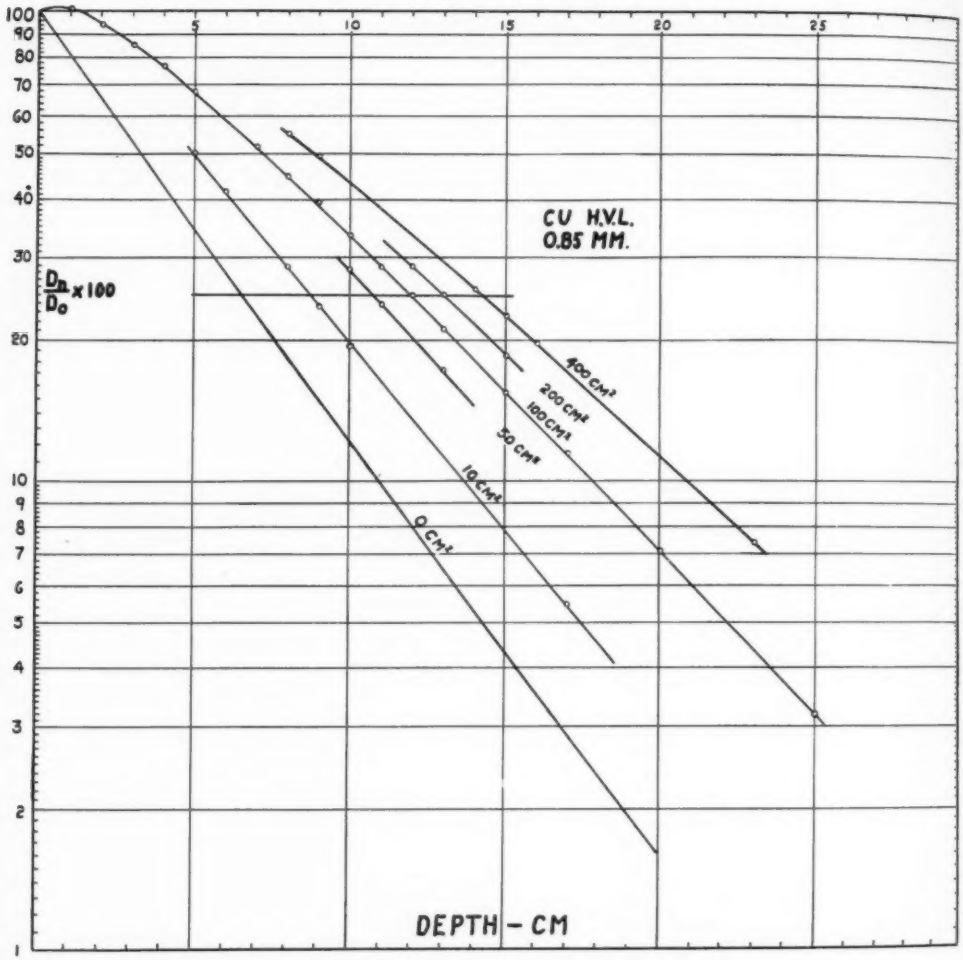


Fig. 9*d*. D_n/D_0 ratios, 70.7 cm. f.s.d.

or 2 per cent[6] from the curve, a mistake was found in the slide-rule calculation. An exception which is probably due to an experimental blunder is seen on the 400-cm.^{2} curve of Figure 9*i* at 22.5 cm. depth.

An example of the reproducibility, as distinguished from the precision, of the measurements is given by the D_n/D_0 ratios for 100 cm.^{2} in Figure 9*e*. The data represented by circles in this graph were taken in June 1941. During the summer the phantom and all positioning installations were taken down in order to make some alterations in the x-ray generator. The following January, with the apparatus again set up and completely realigned, the measurements shown on the curve by squares were made. On various other occasions parts of curves were repeated with similar agreement.

The curves for zero area (primary beam without scatter) shown in Figures 9*a–i*, are obtained by combining the narrow

[6] In examining the curves, it is useful to bear in mind that on logarithmic rulings a given displacement from the curve (in actual distance, *e.g.*, 10 mm.) represents the same *fractional* deviation on all parts of the scale. For example, the ordinate distance from 10 to 11 is the same as from 50 to 55. Hence, any point whose deviation from the curve is equal to the distance between 98 and 100 per cent rulings shows a fractional deviation of 2 per cent.

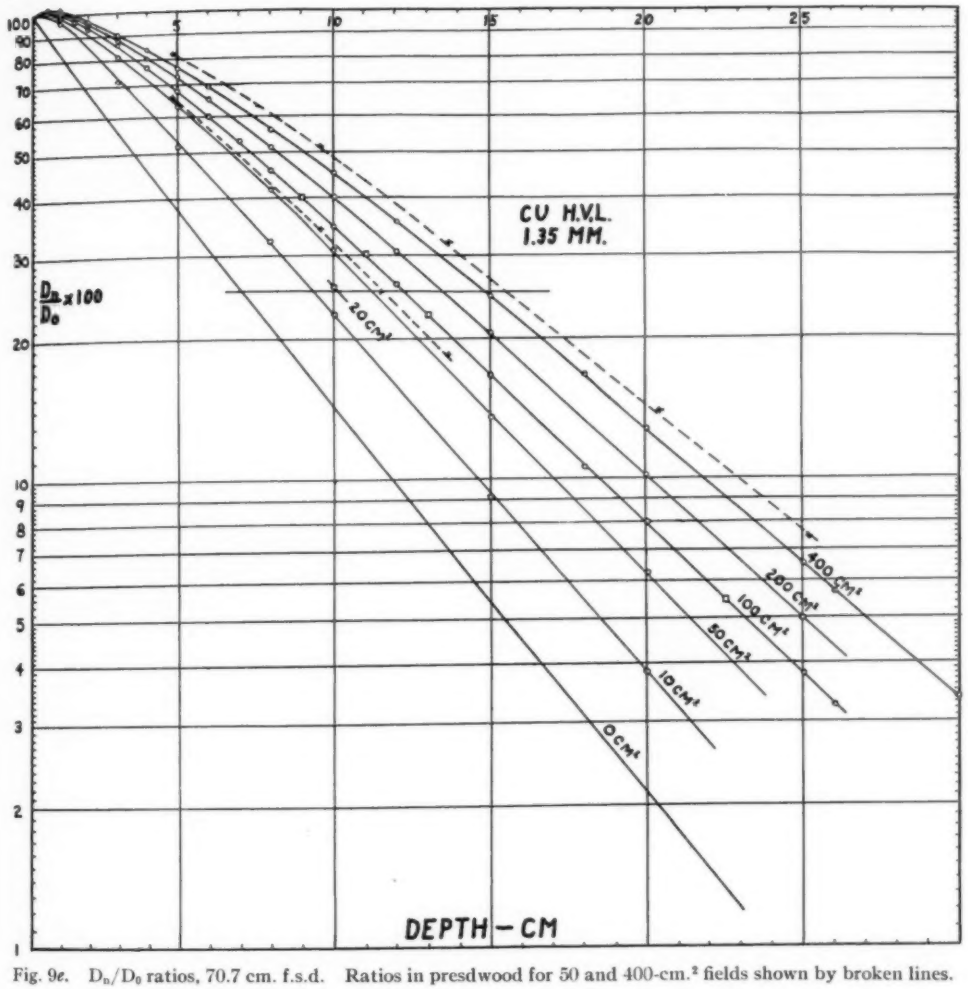


Fig. 9*e*. D_n/D_0 ratios, 70.7 cm. f.s.d. Ratios in presdwood for 50 and 400-cm.² fields shown by broken lines.

beam water transmission curves of Figure 8 with inverse-square law. These curves are slightly concave upward for two reasons. The transmission curve itself is not perfectly straight, and the inverse-square factor curves up slightly on logarithmic paper.[7] In some of the D_n/D_0 curves for narrow beams and low h.v.l.'s this upward curvature is detectable in their lower portions.

In Part 2, a "divergence index" was defined as a means of expressing the average divergence of a beam containing radiation scattered from filters, diaphragms, etc. Curves A and B in Figure 9*k* give D_n/D_0 ratios for two beams having divergence indices of unity and 0.95, respectively. The conditions were the same for the two beams except that for A the filter was 100 cm. above the surface and for B 15 cm. Scatter from the lower filter position increased the free air dose at the

[7] For moderate depths, especially at large f.s.d.'s, the expression $e^{-2d/f}$ gives a fair approximation to inverse-square law for primary beam, where f = f.s.d. and d = distance below the surface. This can be seen from the following comparison:

$$[f/(f+d)]^2 = (1+d/f)^{-2}$$
$$= 1 - 2d/f + 3f^2/d^2 - 4f^3/d^3 + \ldots$$
$$e^{-2(d/f)} = 1 - 2d/f + 2f^2/d^2 - 4/3f^3/d^3 + \ldots$$

For comparison the exponential approximations to three inverse-square curves are shown in Figure 8.

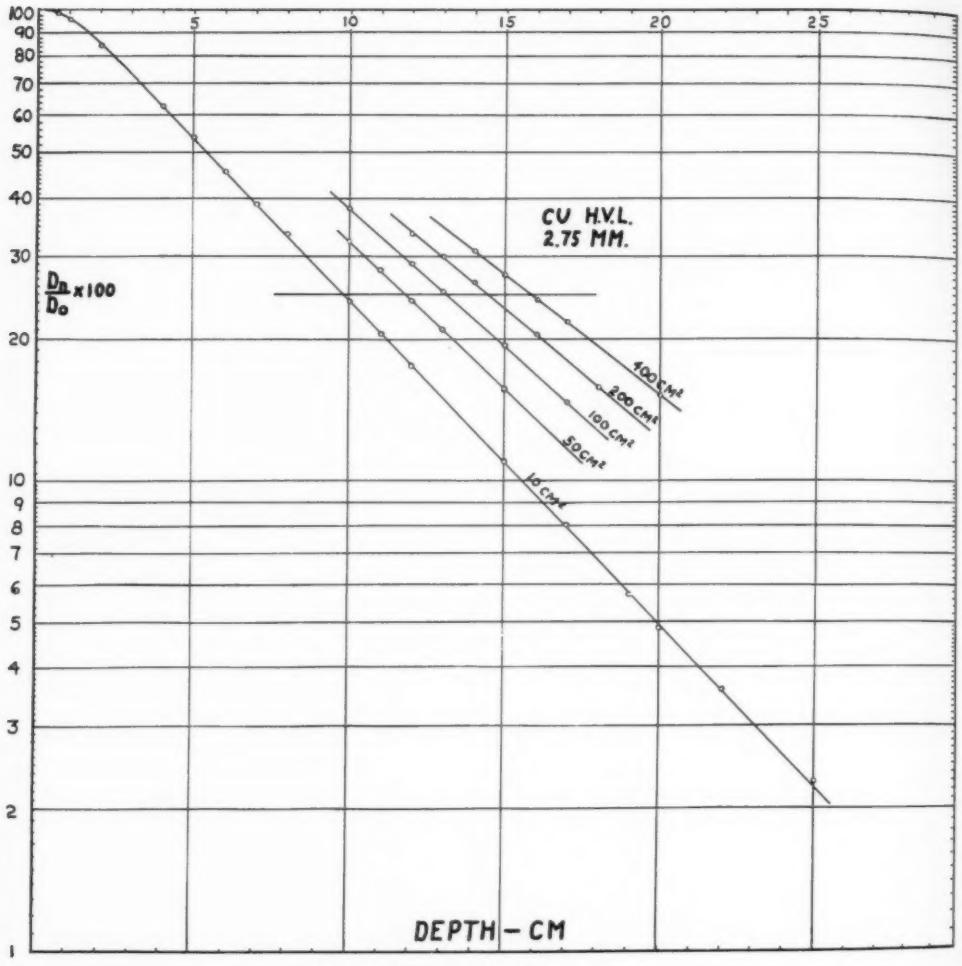


Fig. 9*f*. D_n/D_0 ratios, 70.7 cm. f.s.d.

surface position by 6 per cent, while 25 cm. lower the increase was only 1 per cent. These observations are in accordance with an inverse-square law divergence of the scatter from the filter regarded as the source of the additional radiation. It is seen that in the lower portion of curves A and B, corresponding ordinates differ by 5 per cent. Since at 25 cm. depth the primary beam (Fig. 9*i*) comprises only one-third of the total intensity, it appears that not only the primary beam but also the scatter falls off more rapidly with depth if the divergence index is less than unity. Such a result may be explained by the fact that divergent rays will be scattered into the center of the field from greater distances on the average than will parallel rays. The importance of such an effect would be expected to vary with field size and other conditions. From the present comparison it may be said that D_n/D_0 ratios at the greater depths may in some cases be diminished, at least in proportion to the divergence index.

To observe the effect of non-homogeneity on D_n/D_0 ratios, two beams having a copper h.v.l. of 0.23 mm. and homogeneity coefficients of 2.2 and 1.4 were employed. D_n/D_0 curves for a 100-cm.^{2} field are

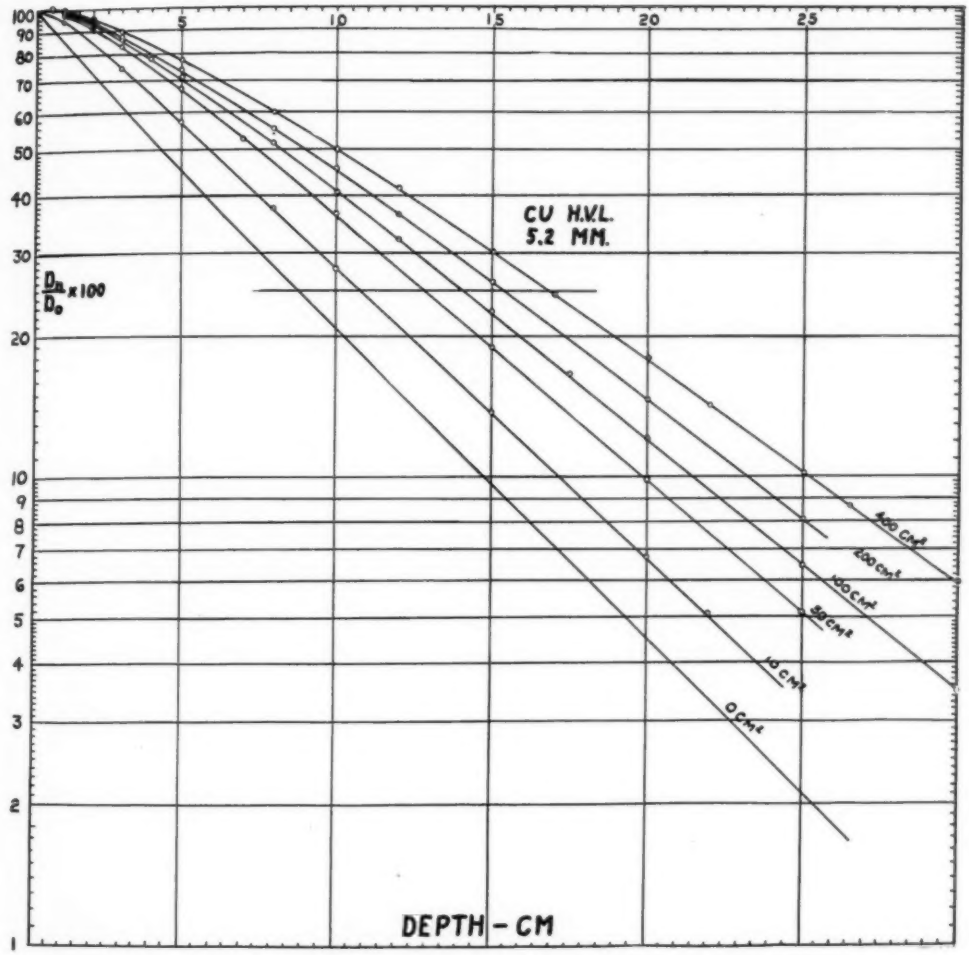


Fig. 9g. D_n/D_0 ratios, 70.7 cm. f.s.d.

given for both beams in Figure 9*b*. These results are discussed in Part 5.

Some measurements in a "presdwood" phantom were made for comparison with the water data. The phantom had the same dimensions as the water phantom. It was made by piling up flat pieces of masonite untempered presdwood 6.7 mm. thick. A close-fitting cavity was made for the dosimeter. The average density of the presdwood was 1.015 gm./cm.^{3} However, it was found that the density of individual pieces cut from the same large sheet varied from 0.96 to 1.07 gm./cm.^{3} Light and heavy pieces were alternated in the phantom.

In Figure 9*e*, D_n/D_0 ratios in presdwood for 1.35 mm. Cu h.v.l. and 50 and 400 cm.^{2} are shown by broken lines. It is seen that at 25 cm. depth and a 400-cm.^{2} field the ratio for presdwood is 15 per cent larger than for water. At 8.7 mm. Cu h.v.l., 12.5 cm. depth, and 400-cm.^{2} field the D_n/D_0 ratio was only 2 per cent higher than for water. At both h.v.l.'s the D_0/D ratios were smaller than for water by less than 2 per cent. Some narrow beam transmission measurements were also made on presdwood, with results as shown in Table III.

A few narrow beam transmission meas-

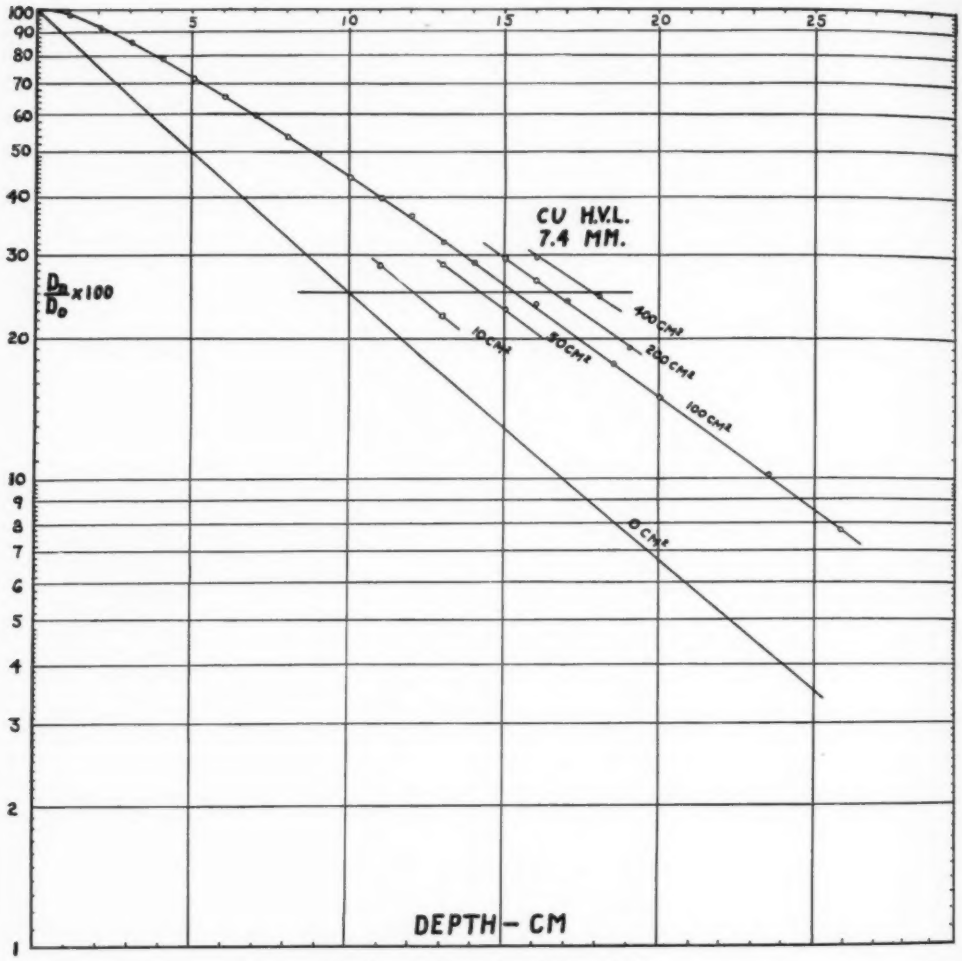


Fig. 9*h*. D_n/D_0 ratios, 70.7 cm. f.s.d.

TABLE III: COMPARISON OF NARROW BEAM ABSORPTION COEFFICIENTS OF PRESDWOOD AND WATER

Cu h.v.l. →	0.23 mm.	0.85 mm.	1.35 mm.	5.2 mm.
$\frac{\mu/\rho \text{ presdwood}}{\mu/\rho \text{ water}}$	0.90	0.93	0.85	0.95

μ/ρ-mass absorption coefficient. The ratios given for the last two h.v.l.'s may be wrong by as much as 5 per cent because the presdwood was not selected for average density.

urements were also made for beef muscle and for beef suet (fat tissue). The muscle was ground and packed into one of the containers used for the water transmission measurements as described in Part 3. The suet was packed in the container with a little water to fill the spaces between pieces. The results of these tests with muscle and one with fat are shown in Table IV. The thickness given includes 1 mm. celluloid. The ratio of average linear absorption coefficients for tissue and water (line 4, Table IV) were obtained by comparison with the I/I_0 curve for water at the same h.v.l. in Figure 8. The variation in the results for muscle may be due to the difficulty in packing the ground meat free from air spaces. In the first two trials it was packed under water; in the last without water. The values for suet have been cor-

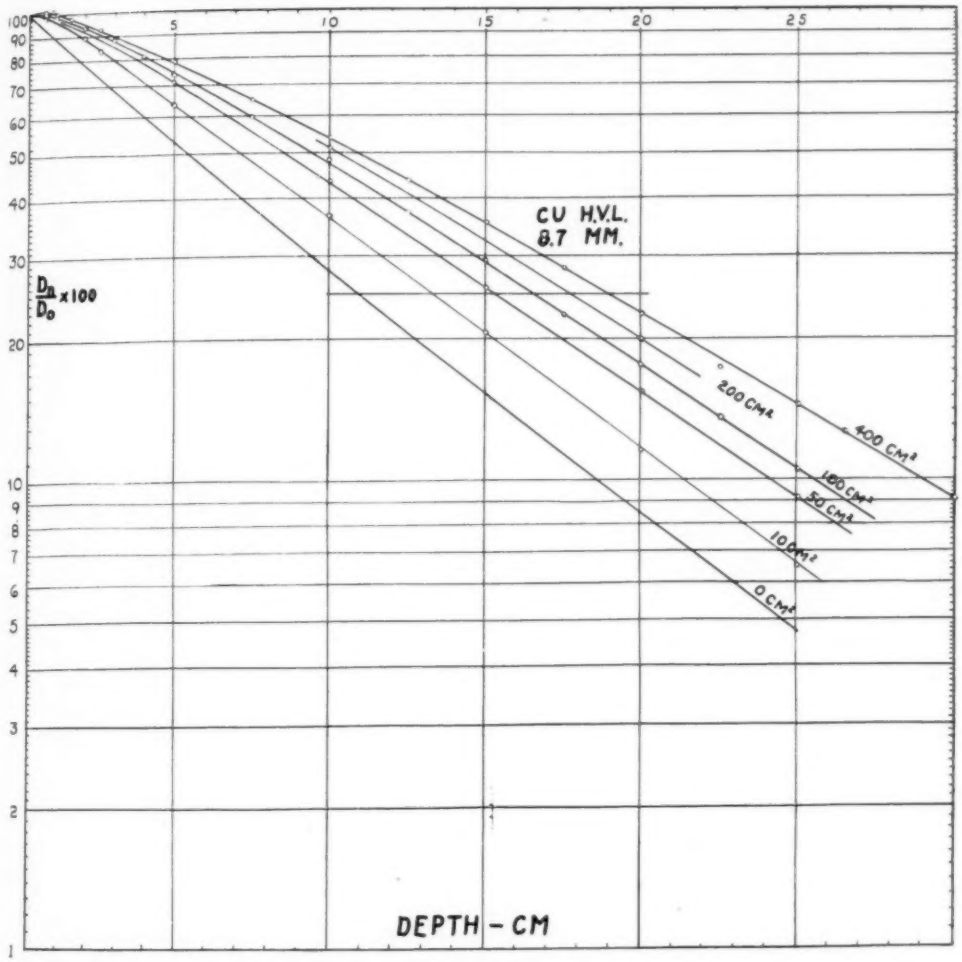


Fig. 9*i*. D_n/D_0 ratios, 70.7 cm. f.s.d.

TABLE IV: NARROW BEAM TRANSMISSION MEASUREMENTS FOR BEEF TISSUE
(Cu h.v.l. 0.23 mm. h = 2.2)

	Muscle			Suet
Thickness (cm.)	4.05	4.80	6.05	4.8
Density (gm./cm.³)	1.030	1.028	1.026	0.90
I/I_0	0.380	0.303	0.217	0.36
$\frac{\mu \text{ tissue}}{\mu \text{ water}}$	0.97	1.00	1.04	0.87

I_0 = initial intensity. I = transmitted intensity.
μ = linear absorption coefficient.

rected for 0.7 cm. water used to fill the spaces.

A few exit intensities were measured with a special shallow water phantom having a presdwood bottom 18 mm. thick. The chamber was held in a "half emerged" position in a close-fitting depression in the exit surface. The phantom was supported by the edges so that the exit beam had a clear path to the floor. Back-scatter from the floor was inappreciable. The exit intensities measured are given in Table VI and will be discussed in Part 5.

PART 5. DISCUSSION OF RESULTS

Experimental values of D_0/D and D_n/D_0 ratios having been obtained as described in Part 4, the problem remained to present the information in a form suitable for con-

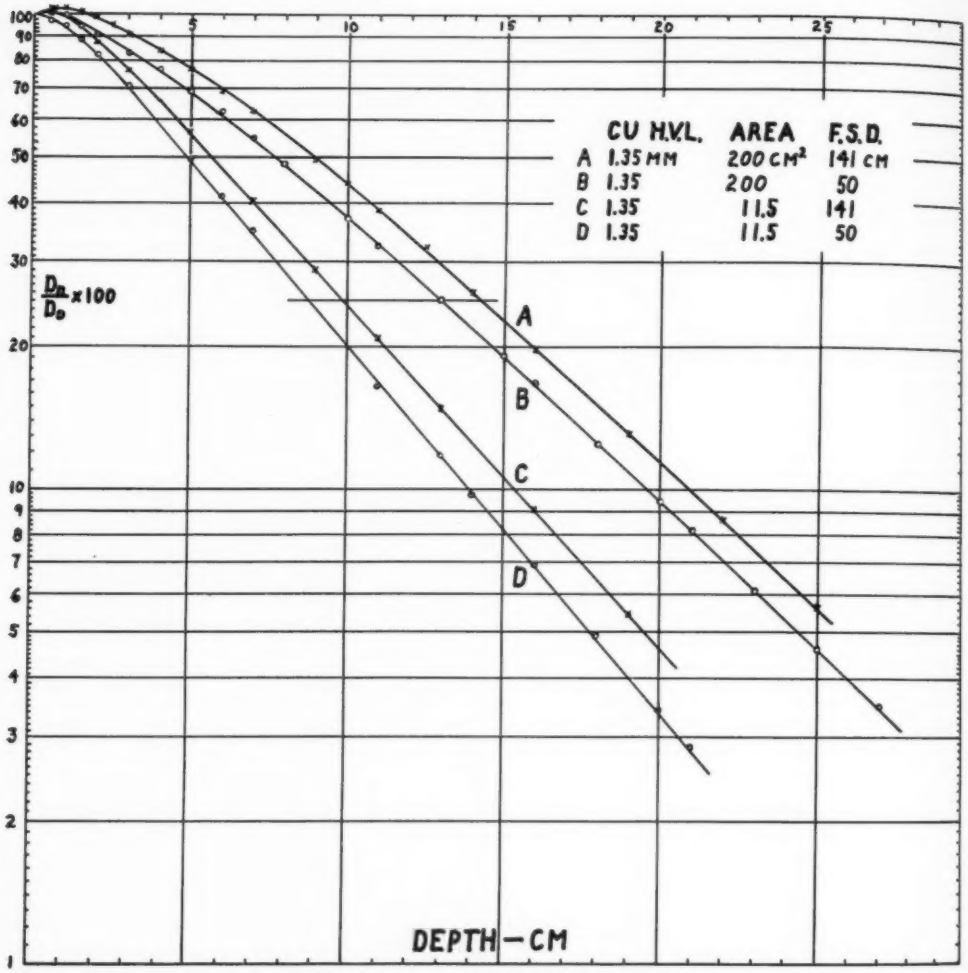


Fig. 9*j*. D_n/D_0 ratios, 50 and 141 cm. f.s.d.

venient interpolation. A tabular method of presentation would have required an excessive amount of space. Furthermore, this method is poorly suited to exhibiting the orderly trends which are found in the data.

A method was devised to display all D_n/D_0 ratios by means of a few charts. These charts, while unfamiliar in form, are extremely simple to use. Furthermore, they show at a glance the relationships between ratios for different sets of conditions.

The method employed in obtaining these charts from the curves of Figures 9*a–k* is based on the similarity in shape of the curves, which appears when they are modified according to a simple procedure. This modification consists in adjusting the abscissa scale of each curve so as to make all the curves pass through an arbitrarily chosen point.

Explanation of D_n/D_0 Charts: In Figures 9*a–k* the measured values of depth to surface ratio, D_n/D_0, are plotted against depth in centimeters on semilogarithmic rulings. It was discovered that, by suitable adjustment of the depth scale for each curve, all the D_n/D_0 curves could be approximately superimposed on one another. For any one curve the adjustment con-

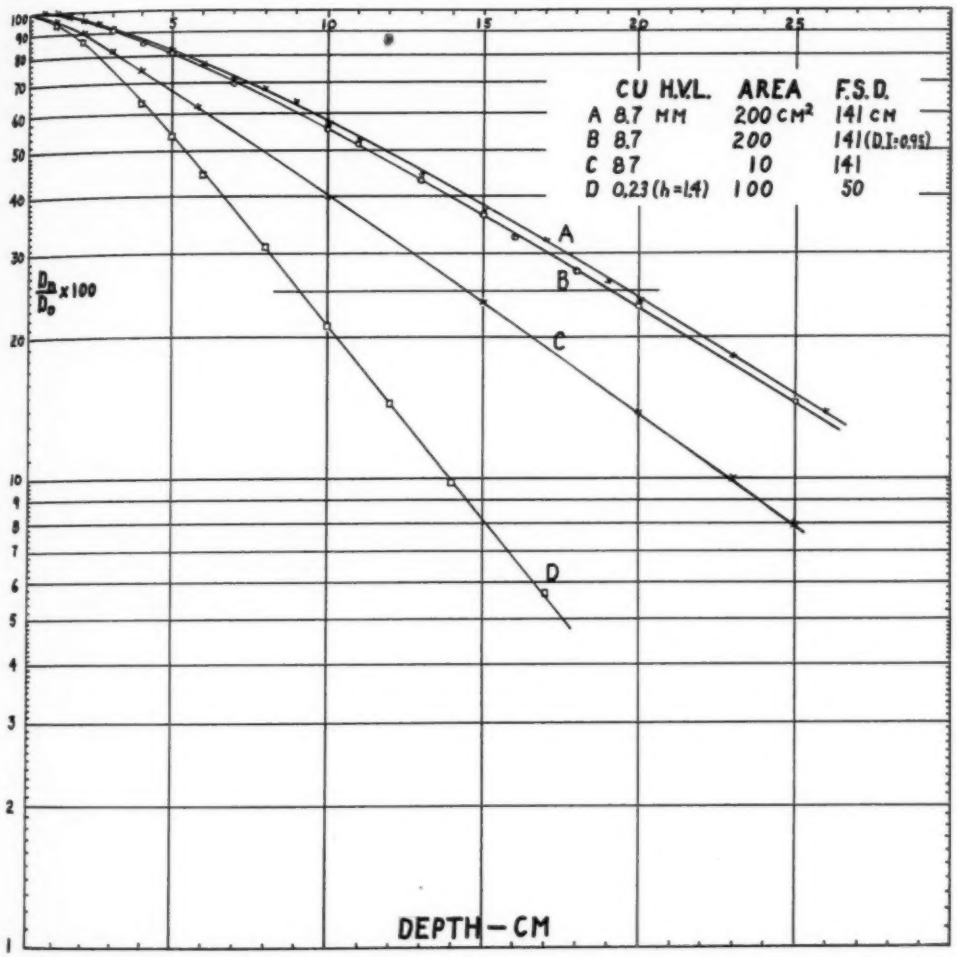


Fig. 9*k*. D_n/D_0 ratios, 50 and 141 cm. f.s.d. Curve A: Divergence index 1.0. Curve B: Divergence index 0.95.

sisted in "shrinking" the abscissa of each point of the curve by a constant factor chosen so as to make the curve pass through the intersection of the rulings for 25 per cent and 5 cm. depth. The factor required for this adjustment of any curve will be called the "depth factor" for that curve. This procedure is illustrated in Figure 10 and further explained in the caption.

One curve from the midst of the group of "shrunken" curves was arbitrarily chosen as a "Standard D_n/D_0 Curve." By "stretching" the Standard Curve in accordance with the depth factor corresponding to any particular set of conditions, an approximate D_n/D_0 curve can be obtained for those conditions.

To facilitate the process of shrinking and stretching the abscissa scale of D_n/D_0 curves, a further modification has been made in the method of plotting the curves. This consists in altering the ordinate (percentage) scale in such a way as to change the Standard Curve into a straight line. The way in which this is done is shown in Figure 11.

From the straightened Standard Curve it

is a simple matter to get an approximate D_n/D_0 curve for any set of conditions for which the depth factor is known. All that is necessary is to draw a straight line on Figure 13 from the upper left corner through the appropriate factor. From the logarithmic rulings the plotted data fall close to straight lines. As explained previously, the field sizes employed were close to, but not exactly, even hundreds of square centimeters. Factors taken from Figure 14 for even values of field sizes are

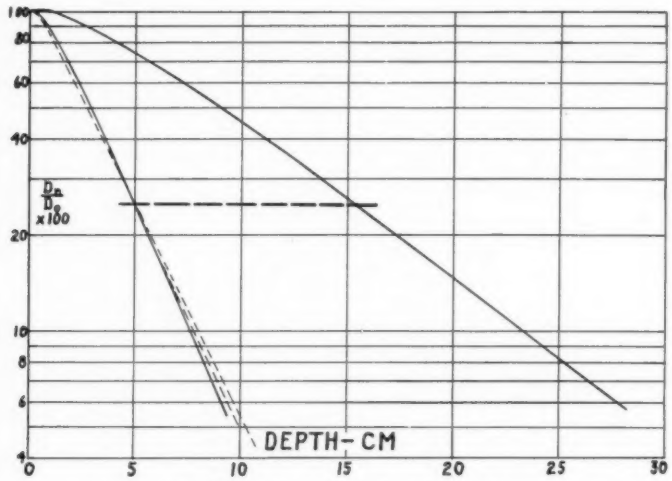


Fig. 10. Derivation of Standard D_n/D_0 Curve.

The curve at the right is the D_n/D_0 curve for h.v.l. 5.2 mm. Cu, area 200 cm.², f.s.d. 70.7 cm., taken from Fig. 9. This curve crosses the 25 per cent line at 15.3 cm. depth.

Let the abscissa (depth) of each point of the curve be divided by a "depth factor" F = 15.3/5 = 3.06. A new curve will be obtained which will cross the 25 per cent line at 5 cm. This is the Standard Curve shown by the solid line at the left.

The factor by which any D_n/D_0 curve must be shrunk to make it cross the 25 per cent line at 5 cm. will be called the "depth factor," F, for that curve. The depth factor for any curve is the depth at which it crosses the 25 per cent line divided by 5.

Curves which have been shrunk in the way just described may be plotted along with the Standard Curve for comparison. The dotted curves in the figure represent D_n/D_0 curves for 10 and 50 cm.² taken from Fig. 9 for the same h.v.l. and f.s.d. as curve A. The curves for 100 and 400 cm.² lie so close to the Standard Curve as to be indistinguishable.

The depth of 5 cm. was chosen for the intersection point in order that the Standard Curve should lie to the left of all the actual D_n/D_0 curves, and so that all depth factors would be greater than unity. By making the curves cross at the 25 per cent level, the divergences between curves are about equally divided above and below this level for the range of depth measured. The divergences are very small at the depths of most clinical importance.

similar triangles which are thus formed, it is evident that this procedure corresponds to multiplying each abscissa of the Standard Curve by the same factor.

Values of Depth Factors: In Figure 14 the depth factors, F_{70}, for all the D_n/D_0 curves measured at 70.7 cm. f.s.d. (see Fig. 9 *a–i*) are plotted against field area for all the h.v.l.'s employed in the measurements. It is seen that on double plotted against half-value layer in Figure 15. Factors may be taken from either Figure 14 or 15 according to convenience.

For focal skin distances much different than 70 cm., a small correction in the depth factor F_{70} is required. For any focal skin distance the depth factor F can conveniently be given by multiplying the factor F_{70} by a correction factor F_d.

The way in which values of F_d were ob-

TABLE V: DEPTH FACTOR CORRECTION FOR FOCAL SKIN DISTANCE

h.v.l. mm. Cu	Field area cm.²	F_d for 50 cm. f.s.d.	F_d for 141 cm. f.s.d.
0.23 (h = 1.4)	0	0.96	...
	100	0.97	...
1.35	0	0.94	1.07
	11.5	0.92	1.03
	200	0.97	1.05
8.7	0	...	1.11
	10	...	1.08
	200	...	1.11

tained will now be explained. A few measurements were made of D_n/D_0 ratios at 50 cm. and at 140 cm. These measurements, at three h.v.l.'s and three areas, are given in Figures 9*j* and *k*. For any h.v.l. and area and focal skin distance, the *ratio of the depth factor F to the factor F_{70} for 70 cm. f.s.d. is the correction factor*. Values of F_d obtained by comparison of the curves of Fig. 9*j–k* with the corresponding curves for 70 cm. f.s.d. are given in Table V. In the same table are shown values of F_d for zero area (primary beam). The values for zero area were obtained by combining the water transmission curve for each h.v.l. with inverse-square law for each f.s.d. This was done graphically, using tracing paper over semilogarithmic rulings.

By inspection of Table V it is seen that in only one case is the fractional difference between a measured value of F_d and the corresponding value for zero area as large as 4 per cent.

It is concluded that the values of F_d obtained for zero area may be used for all areas with sufficient accuracy for clinical purposes. Figure 16 gives values of F_d calculated graphically from the water transmission curves in Figure 8 for focal skin distances from 30 cm. to infinity. The values for infinity correspond to the transmission curves unmodified by inverse-square law.

Since our data for f.s.d.'s other than 70.7 cm. are rather few, we wished to check the validity of applying values of F_d obtained for zero area to finite field sizes. From the tables of Mayneord and Lamerton (5) we took D_n/D_0 ratios for 50 and 100 cm. f.s.d., for fields of 0, 50, 100, 200, and 400 cm.² and for 1.5, 2.0, and 5.0 mm. Cu h.v.l. These ratios were then plotted on tracing paper over Figure 13. From the resulting curves, the ratio F_{50} cm./F_{100} cm. was obtained for each h.v.l. and field size and compared with the corresponding ratios obtained from Figure 16. Surprisingly good agreement was found, there being no differences larger than 2 per cent.

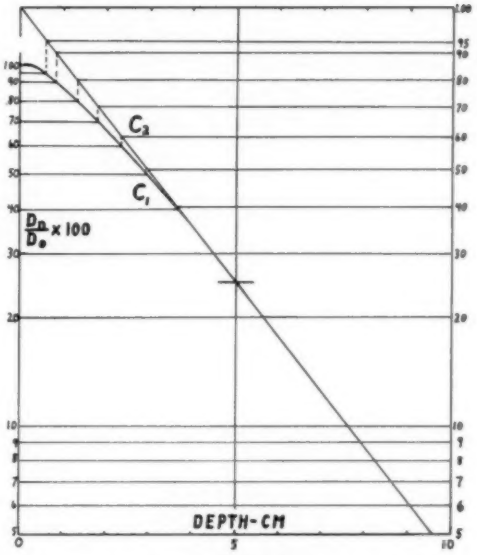


Fig. 11. Method of straightening the Standard D_n/D_0 Curve. It is seen that the Standard Curve (C_1) plotted on semilogarithmic rulings is very nearly straight in the portion of its length corresponding to percentages less than about 35 per cent. The straight portion is continued upward (C_2) until it intersects the left-hand edge of the graph. This intersection is taken to represent 100 D_n/D_0 at the surface (zero depth). Horizontal lines representing 90 per cent, 80 per cent, etc., are obtained by projecting C_1 upward on C_2 as shown.

The same D_n/D_0 values will be obtained from either curve with its associated ordinate scale. For example, at 1.8 cm. either curve gives 70 per cent. It is evident that there is no significance attached to the particular choice of shrinking factor for establishing the Standard Curve. The new scale of ordinates for C_2 could have been obtained just as well from the original curve before shrinking.

It is to be noticed that the straightened curve C_2 is not able to represent the curve C_1 at the beginning where the latter rises slightly above 100 per cent just below the surface. The ordinate scale is left blank over this part of C_2. For information about D_n/D_0 ratios immediately below the surface, refer to the original data in Figs. 9*a–k*.

More Accurate Presentation of D_n/D_0 Ratios: The Standard Curve is only an approximate representation of most of the D_n/D_0 curves of Figures 9*a–k*. While the approximation is accurate enough for most, if not all, clinical requirements, it seems desirable to show all the measured curves in relation to the Standard Curve. This is done in Figures 17*a* and *b*.

If a D_n/D_0 curve is desired for a given set of conditions, the first step is to draw a straight line on Figure 13 for the appropriate depth factor. This line is the expanded Standard Curve, and is an approximate D_n/D_0 curve for the given conditions. The degree of approximation for the particular case can be seen at a glance in Figures 17*a* and *b* by referring to the curve which most nearly corresponds to the conditions in question. If the approximation is not so good as desired, the expanded Standard Curve can be redrawn in accordance with the appropriate curve in Figures 17*a* and *b*. This is easy to do, since the same ordinate scale is used in Figure 13 and Figures 17*a* and *b*. Since ordinates are unaffected by the process of shrinking or expanding the abscissas, ordinate differences from Figures 17*a* and *b* may be transferred directly as corrections to an expanded curve drawn on Figure 13. This can be done with a pair of dividers or simply by eye.

The effect of non-homogeneity is illustrated by the curves of group *b* in Figure 17*a*. The dotted curve corresponds to a well filtered beam, while the other curves of the group are for a poorly filtered radiation.[8] It is to be noticed that the dotted curve and corresponding full line curve cross near the 25 per cent level, so that the "depth factors" are not greatly influenced by homogeneity, at least at low voltages, where homogeneity is less easily obtained with adequate output.

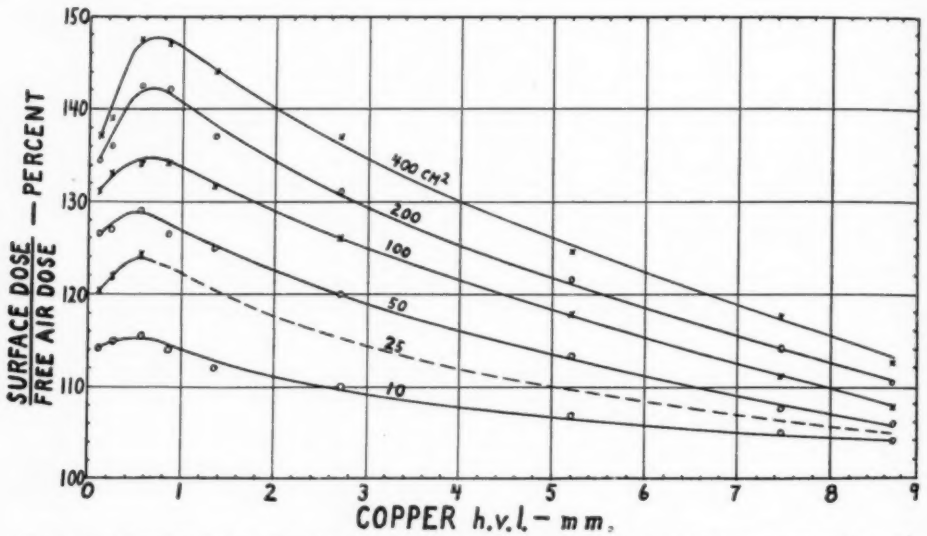


Fig. 12. Measured ratios of surface dose to free air dose. The actual field sizes corresponding to the round numbers shown on the chart were 10, 25, 49, 97, 190, and 385 cm.[2]
The reader may find it convenient to make a graph in which surface to air ratios shown here are plotted against field size for the h.v.l.'s which he customarily employs.

As explained in the preceding section, several D_n/D_0 curves were plotted on Figure 13 using data from the tables of

[8] The lightly filtered beams used in therapy at voltages below about 100 kv. may be much less homogeneous even than those represented by solid lines in group *b* of Figure 17*a*. Dr. Edith Quimby has called our attention to curves for low-voltage therapy beams which differ in shape from ours by a considerable amount, but just in the manner to be expected from Figure 17*a* for their greater inhomogeneity.

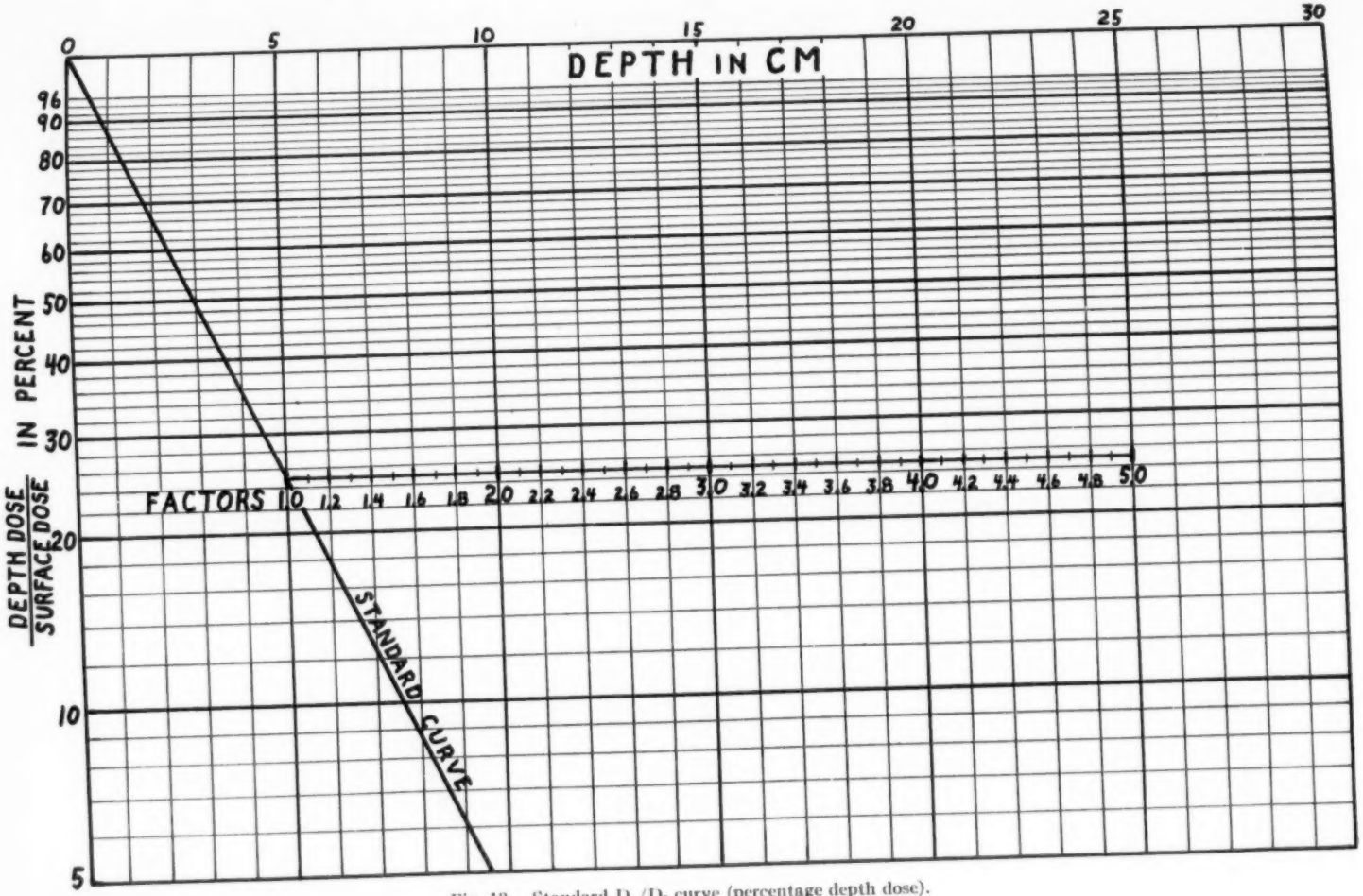


Fig. 13. Standard D_s/D_0 curve (percentage depth dose).

TABLE VI: EXIT INTENSITIES

h.v.l. mm. Cu	Area, cm.²	Depth, cm.	D_e(meas.), r/min.	D, r/min.	D_n/D_0	D_e(calc.), r/min.	$\frac{D_e(calc.)}{D_e(meas.)}$
0.23 (h = 2.2)	200	13.9	5.6	45.4	0.136	6.2	1.10
0.55	100	12.1	6.82	34.7	0.215	7.45	1.09
	100	22.7	1.17	34.7	0.0375	1.30	1.11
7.4	200	17.5	9.95	46.7	0.227	10.6	1.06

D = free air dose.
D_e (meas.) = measured value of exit dose. D_e (calcd.) = $D \cdot D_n/D_0$.

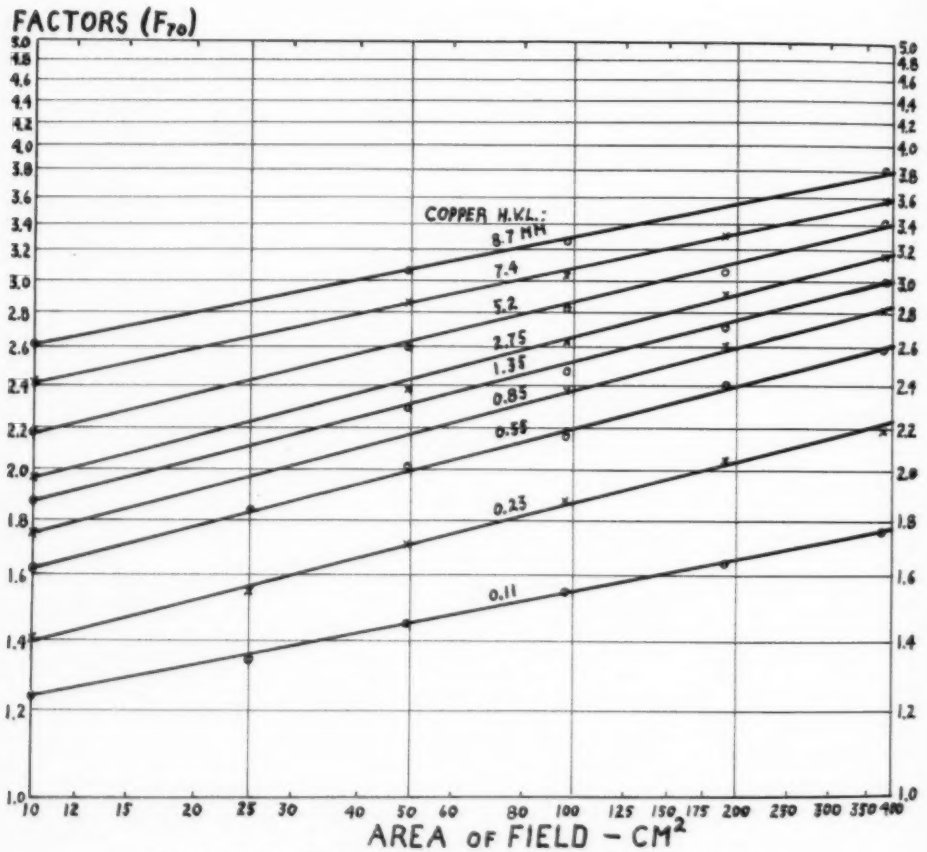


Fig. 14. Factors F_{70} plotted against area on double logarithmic rulings.

Mayneord and Lamerton (5). In most cases the D_n/D_0 ratios of these authors agree with ours well enough to satisfy clinical requirements. However, for small field sizes and 20 cm. depth the values of Mayneord and Lamerton tend to be considerably larger than ours; in one case (5 mm. h.v.l., 100 cm. f.s.d.) by as much as 30 per cent (allowing for the correction to our Standard Curve obtained from Figure 17*a*).

It is gratifying that the values of D_0/D (surface to free air ratios) given by Mayneord and Lamerton agree very closely with our results; the greatest fractional differences being around 3 per cent (*e.g.*,

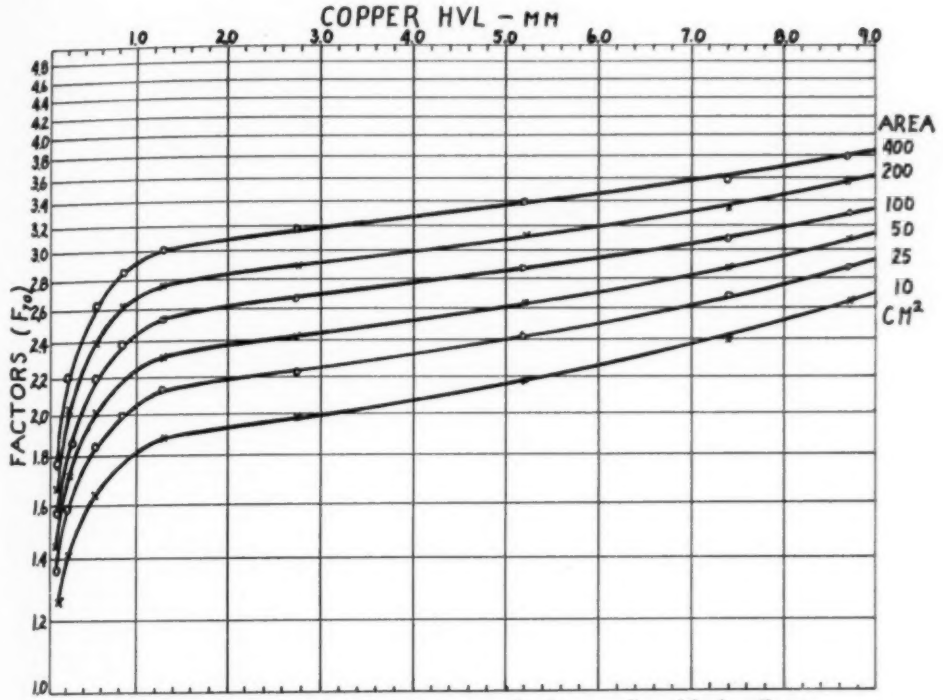


Fig. 15. Factors F_{70} plotted against copper h.v.l. on semilogarithmic rulings.

135 per cent compared to 131 per cent). Their values are nearly all on the low side as compared to ours. The surface to air ratios given by Quimby and others (14) likewise agree with ours within clinical accuracy, the largest fractional difference being 6 per cent on the high side for 0.3 mm. Cu h.v.l. and 400-cm.^{2} area.

Application of D_n/D_0 Ratios to Exposures with Compression Cones: If a layer of organic material is placed on the skin at the entrance portal, the upper surface becomes the effective zero depth. By reference to Figures 9*a–k*, it is seen that at depths of more than 2 or 3 cm. an error of 0.5 cm. in depth usually introduces a fractional error of from 5 to 10 per cent in the D_n/D_0 ratio. This may be avoided by simply including the thickness of covering organic material in the depth.

The skin intensity under 0.5 cm. of covering material (as measured with a thick-walled chamber) may be taken as equal to the surface intensity within 1 or 2 per cent, as may be seen from Figures 9*a–k*.

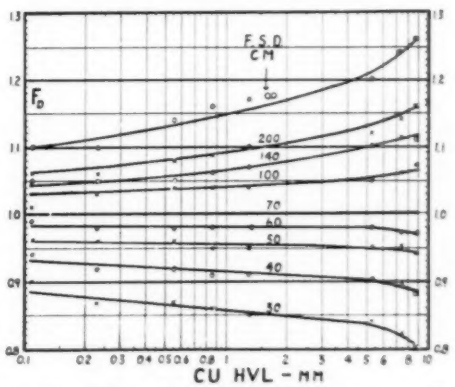


Fig. 16. Values of F_d calculated for zero area. (To be used for all areas.)

While, strictly speaking, the free air dose should be measured at the position of the upper surface of the layer of organic material rather than the skin, the effect of this refinement even at short focal skin distances would be little more than 2 per cent.

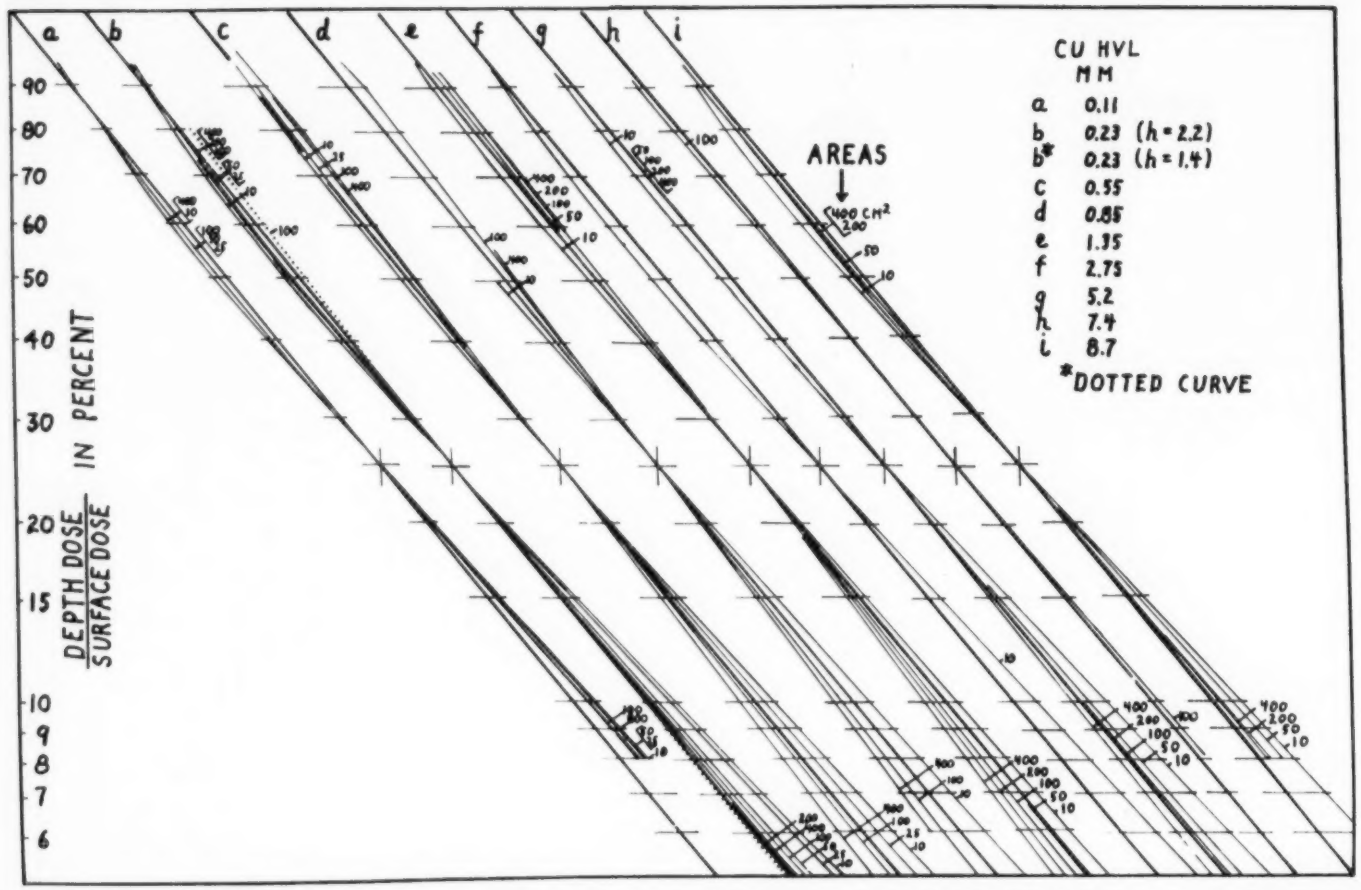


Fig. 17*a*. D_n/D_0 curves compared with the standard curve (heavy straight line); f.s.d. 70.7 cm.

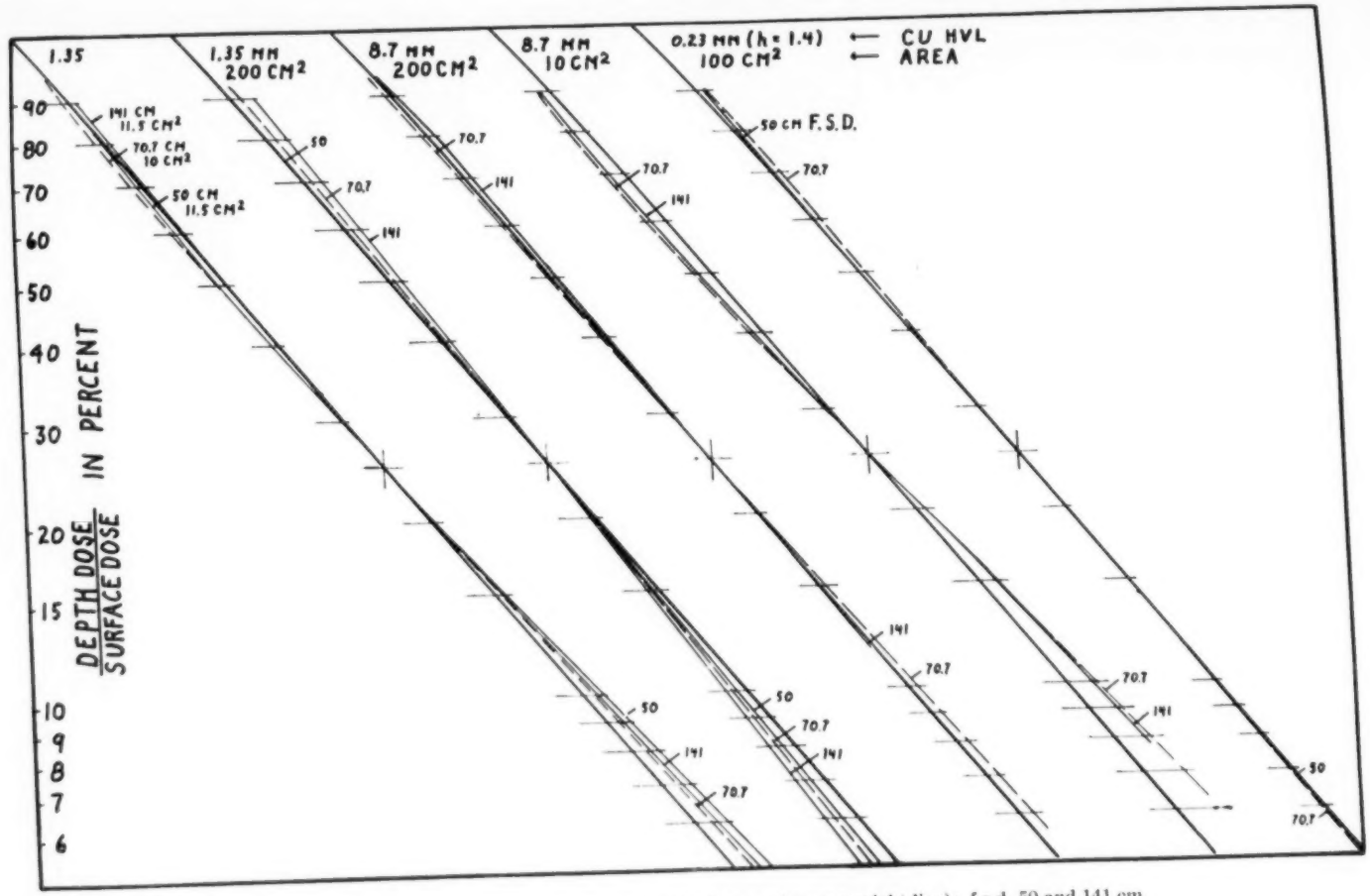


Fig. 17*b*. D_n/D_9 curves compared with the standard curve (heavy straight line); f.s.d. 50 and 141 cm.

Exit Doses: Since the exit dose is usually small, a fractional error of even 10 per cent in its determination will introduce an error of only 1 or 2 per cent in the total cross-fire skin dose.

A few exit intensity measurements were described in Part 4, the results being given in Table VI. These measurements in conjunction with the following discussion suggest a simple procedure for getting exit doses with sufficient accuracy for clinical requirements.

In order to form an approximate picture of exit dose relationships, consider a beam of radiation in an infinitely deep phantom. Assume for the moment that at all depths the same fraction of the forward moving radiation (primary beam plus forward scatter) is scattered backward as at the surface. This amounts to saying that the forward moving radiation is the same fraction of the total intensity at all depths including the surface. Or, since the forward moving radiation at a given depth may be taken as the exit intensity:

$$D_e/D_n = D/D_0.$$

Hence:

$$D_e = (D/D_0)\cdot D_n = D\cdot(D_n/D_0).$$

Or, the exit dose is equal to the free air dose multiplied by the depth to surface ratio.

The relation just derived will not be expected to hold very closely, since the fraction of radiation scattered back is certainly not the same at all depths, as was assumed. However, all the exit doses calculated in this way, and shown in Table VI, are in error on the "safe side," from a clinical standpoint, being 6 to 11 per cent larger than the corresponding measured values.

Depth Factor as an Index of Penetration: Referring to Figure 13, it is seen that the depth factor for any beam is proportional to the depth at which a D_n/D_0 ratio (percentage depth dose) of 25 per cent is obtained. To the degree of approximation to which the actual D_n/D_0 curves are represented by the Standard Curve (see Figures 17*a* and *b*), the same statement applies for all D_n/D_0 ratios. Thus the depth factor is a convenient measure of the "penetration" of a beam, and the ratio of the depth factors of two beams is an index of their relative penetration. The relation of penetration to h.v.l., field size, and f.s.d. may be studied in Figures 14, 15, and 16.

Inspection of Figure 14 shows that improvement in penetration with increasing h.v.l. is not limited to small field sizes. For example, in going from 1.35 to 8.7 mm. h.v.l. the depth factor increases by 33 per cent for 50-cm.^{2} and 27 per cent for 400-cm.^{2} fields.

It is of interest to compare the depth factors obtained from Figure 15 for three beams of 100-cm.^{2} area: (*a*) 200 kv., 0.5 mm. Cu filter, 1 mm. Cu h.v.l.; (*b*) 400 kv., 2 mm. Cu filter, 4 mm. Cu h.v.l.; (*c*) 1,000 kv., 9 mm. Cu h.v.l. The corresponding depth factors are 2.45, 2.77, and 3.33. It is seen that the 400-kv. beam has 13 per cent and the 1,000-kv. beam 36 per cent more penetration than the 200-kv. beam.

Arrangements have been made to furnish at cost positive photostats (black lines on white) of the original drawings for Figures 12, 13, 14, 15, 16, 17*a* and *b*. Figure 13, for example, is 9 in. × 14 in. The set may be had by sending $2.00 to H. A. Rogers Co., 815 Marquette Ave., Minneapolis 2, Minn. Extra copies of Figure 13 may be had for $0.35 each. One or two of these may be useful as work sheets in preparing dosage tables for the reader's customary treatment conditions. Or the appropriate lines drawn on Figure 13 may be used in place of percentage depth dose tables.

A copy of the *Summarized Instructions for Using Dosage Charts*, appearing on page 399, will be furnished with the charts.

Summarized Instructions for Using Dosage Charts

It is desired to find surface intensity, D_0, depth intensity, D_n, and exit intensity, D_e, for given values of half-value layer, field size, and focal skin distance.

These results, for points on the axis of the beam (center of field), are obtained in the following steps:

1. Measure the free air intensity, D, in r/min. at the point corresponding to the center of the skin field (*e.g.*, 20 r/min.).

2. From Figure 12 find the value of the "Surface to Air Ratio" D_0/D, for the given h.v.l. and field size. Multiply D_0/D by D to get the surface intensity, D_0 (*e.g.*, 125 per cent of 20 r/min. = 25 r/min.).

3. In step 4, a "depth factor," F, will be required. From Figure 14 or 15 find the factor F_{70}, which is the desired depth factor in cases where the focal skin distance is 70 cm.

In case the f.s.d. is larger or smaller than 70 cm., obtain a correction factor, F_D, from Figure 16. Multiply F_{70} by F_D to get the depth factor F.

4. On Figure 13 draw a straight line from the upper left-hand corner through the point on the 25 per cent line corresponding to the depth factor, F, just obtained.

The straight line thus drawn will be an approximate D_n/D_0 (percentage depth dose) curve for the given conditions.

The depth intensity, D_n, for any desired depth may be obtained by multiplying the D_n/D_0 ratio for that depth by the value of D_0 obtained in step 2 (*e.g.*, 20 per cent of 25 r/min. = 5 r/min.).

5. The special ordinate scale of Figure 13 was chosen so that the straight line (Standard) D_n/D_0 curves would approximate the actual curves closely enough for clinical requirements, except possibly in some cases for the smallest field sizes (around 10 cm.^{2}).

The degree of approximation can be seen in any particular case by examining curves in Figures 17*a* and *b* for conditions similar to those under consideration. If desired, the straight line curve drawn in Figure 13 can be corrected by transferring to it the ordinate deviations found in an appropriate curve in Figures 17*a* and *b*. This is easily done with a pair of dividers, or simply by eye, since the same ordinate scale is used in Figures 13 and 17, and since ordinate relations are unaffected by the different abscissa scales.

6. If the skin is covered with a layer of organic material, the thickness of this layer should be added to depths below the skin surface. The skin dose will be practically unaffected by the additional material. (This last statement refers to x-ray dosage in roentgens and does not exclude the possibility of an appreciable effect of the surface layer on secondary electron equilibrium with high-voltage radiation.)

7. To get an approximate value of the exit intensity, simply multiply the D_n/D_0 ratio for the depth of the exit surface by the free air intensity, D (*e.g.*, 20 per cent of 20 r/min. = 4 r/min.). It appears that exit doses obtained in this way are likely to be from 5 to 10 per cent higher than actual values. Since the exit dose is usually only a small part of the total cross-fire dose, this error, which is on the "safe" side, is of no importance.

ACKNOWLEDGMENTS: The work which has been described was begun and carried on for several years under the direction of Professor Francis C. Wood. It is a special pleasure to express our thanks to him, both for his valuable suggestions and continuing interest and for his unfailing support in the task of developing a generator suitable for experiments of this type. We are grateful to the Markle Foundation for financial support during a part of this investigation. For generous cooperation in connection with the development of the Sloan x-ray generator, we are indebted to Professor E. O. Lawrence, Dr. D. H. Sloan, the Research Corporation, the Chemical Foundation, and the Allegheny Steel Company. The General Electric Company cooperated by designing special power supply equip-

ment. The Columbia Presbyterian Hospital furnished convenient quarters for housing the x-ray generator and laboratory. Among individuals too numerous to list who helped in the construction of the generator, we wish especially to mention the late Dr. Wesley Coates, Mr. Arthur Chick, Mr. Darrow Haagensen, Mr. E. E. Gyana, Mr. Frank Matthews, and Mr. George Roch.

4136 Abbott Ave., S.
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EDITORIAL

Radiology and Physics

Advancing radiological technique brings with it problems of organisation and human relationships. An important example arises in radiation therapy, where the closest collaboration between radiologist and physicist is now recognised to be essential; yet even to most physicists the problems appear strange and bewildering, and it is scarcely surprising that medical radiologists find increasing difficulty in following the detailed mathematical and physical studies of the techniques which are now emerging.

We may take the view that the medical man has so many problems of his own that it is quite impossible and undesirable for him to attempt to follow these details, and similarly the physicist may find what is to the radiologist the most elementary anatomy and pathology a maze of hopeless sounds. Unless the medical radiologist understands something at least of the power and limitation of the physical methods, he will certainly not be able to make best use of his physical colleagues, who in their turn will be unable to make relevant suggestions of alteration in technique or criticisms of present procedures unless at least superficially acquainted with the medical radiologist's mode of speech.

One of the most efficient ways of bringing together these two groups of people with divergent methods of training, and therefore outlook, lies in the physicist attending regularly at radiological clinics and seeing there the difference between a neat diagram of radiation fields and cancer in its most unmathematical forms. The radiologist on his part will find regular visits to an experimental laboratory stimulating and perhaps chastening experiences.

A good deal might be done to relieve the situation by a more systematic training of the hospital physicist. Frequently even a change in mathematical approach to a problem will make collaboration much easier. For example, it will be found in studying radiation distributions that the medical radiologist will visualize results much more clearly if the physicist avoids formal mathematical analysis, substituting geometrical methods. A formula is anathema, but the shape of an isodose surface is almost anatomy. The physicist, too, is apt to think his job is done when he states, let us say, "that for a length of 2.7 cm. the dose in a certain plane does not fall below 90 per cent." Such a statement means little to most medical radiologists, but expressed in the form that "the 90 per cent isodose surface stretches anteriorly from the lower border of the hyoid bone to the upper border of the cricoid cartilage" instantly brings a look of relief and gratitude. This method of approach implies that the hospital physicist should be instructed in elementary anatomy, so as to be able to take a more intelligent interest in the parts of the body he helps to treat, as well as to be able to transmit his hard-won information in a more acceptable form to his medical colleagues. The anatomy taught to the physicist should of necessity be of rather a special variety, which we might describe as "geometrical anatomy." Size, shape, and position are of more importance to him than structure or function, which clearly lie outside his province.

It must be emphasized that the correct physical approach to a therapeutic problem lies in the recognition of the paramount importance of the tumour dose in roentgens. One cannot help feeling, look-

ing at the present-day techniques, that we are still hypnotised by the skin. From a physical point of view the rational way of planning a treatment is to decide the shape and extent of the volume which we wish to treat and deduce from this information the size and shapes of the fields we should employ on the surface. So far, little work of this kind has been done, and how far it may prove possible in practice we do not yet know, but it seems, from the physical point of view, the right way of beginning. Moreover, the treatment should be planned before it commences, and the physical investigations be more than a postmortem study of the errors we have made.

It has usually been thought that too close a reliance on physical methods leads to cast-iron techniques and standardised dosage. This is indeed a grave error, and the reverse is more nearly true. There can be no doubt that variation of size and condition from patient to patient is of the utmost importance, and the standardisation of technique is becoming increasingly indefensible, since the detailed physical studies now provide the necessary information to enable adjustment of technique from patient to patient to be made on a rational basis. Such physical studies tend towards flexibility rather than standardisation. This is an important lesson for both radiologist and physicist to learn, and they are more likely to learn together than separately.

Only the closest personal collaboration of radiologist and physicist, only the daily discussion of mutual problems, only the realisation that the medical man has final responsibility but the physicist an indispensable interest, can solve the problem of one of the most important applications of science in medicine. The physicist must realise that, however fascinating and important his more academic problems, his primary responsibility in this respect is to be useful, while on the part of the medical radiologist we should ask for a more enlightened understanding of the importance of the physicist not only in solving the technical day to day problems, but also as a spearhead of the attack on the fundamental biophysical problems of the structure of living material and its interaction with radiation.

W. V. MAYNEORD
Physics Department
The Royal Cancer Hospital (Free)
London

CLEVELAND RADIOLOGICAL SOCIETY

In commemoration of the semicentennial anniversary of Roentgen's discovery of x-rays, exhibits and lectures are being jointly planned by the Cleveland Radiological Society and the Museum of the Cleveland Medical Library. Dr. Otto Glasser, eminent Cleveland physicist and friend of Roentgen, is conducting the arrangements.

Current officers of the Cleveland Radiological Society are John O. Newton, M.D., President; J. Robert Andrews, M.D., Vice-President; Don D. Brannan, M.D., Secretary-Treasurer.

DENVER RADIOLOGICAL CLUB

At a recent meeting of the Denver Radiological Club, Dr. George Unfug of Pueblo was elected President; Dr. John H. Jamison of Denver was elected Vice-President; Dr. Leonard G. Crosby and Dr. A. Page Jackson, Jr., were re-elected Treasurer and Secretary, respectively.

PENNSYLVANIA RADIOLOGICAL SOCIETY

The next meeting of the Pennsylvania Radiological Society will be held May 5 and 6, at the William Penn Hotel, Pittsburgh.

CANCER TEACHING DAY

A Cancer Teaching Day program will be presented at the Hotel Statler, Buffalo, N. Y., on April 26, under the auspices of the Erie County Medical Society, the Buffalo Academy of Medicine, the Medical Society of the State of New York, the University of Buffalo School of Medicine, and the Division of Cancer Control of the New York State Department of Health.

The speakers will be Dr. Donald Guthrie on "Diagnosis and Surgical Treatment of Carcinoma of the Breast;" Dr. Lloyd F. Craver on "What Can the General Practitioner Do About Lowering Cancer Mortality?" Dr. Hayes Martin on "The Diagnosis and Curability of Intraoral Cancer;" Dr. John H. Garlock on "Carcinoma of the Colon."

Letter to the Editor

Dear Sir:

It is with sincere pleasure that we have noticed and welcomed the regular attendances of an increasing number of U.S.A.M.C. roentgenologists at the scientific meetings of our three Radiological Societies—the British Institute of Radiology, the Faculty of Radiologists, and the Section of Radiology of the Royal Society of Medicine.

Usually, the three Societies hold their meetings on the third Thursdays and Fridays in each month, in London.

We write as the Presidents of the three Societies to express the appreciation we have all felt of the interest shown and of the part played in discussion by our American radiological colleagues, and to say that their continued attendances will be warmly welcomed whilst they remain in Britain. Many of us wish that we could have offered more private hospitality, but this has been difficult to achieve because of numerous wartime restrictions.

Our American visitors have undoubtedly helped towards the continued success of our meetings, which are by no means easy to arrange because of the extreme pressure of work on radiologists at the present time, and secondarily because of travelling difficulties.

We remain,
Yours sincerely,
ROHAN WILLIAMS
(British Institute of Radiology)
RALSTON PATERSON
(Faculty of Radiologists)
J. L. GROUT
(Section of Radiology, Royal Society of Medicine)

Post-script: Full information may be obtained from the Secretaries at:

British Institute of Radiology, 32, Welbeck Street, London. W.1.
Faculty of Radiologists, 45, Lincolns Inn Fields, London. W.C.
Section of Radiology, Royal Society of Medicine, 1, Wimpole Street, London. W.1.

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

SUPER-VOLTAGE X-RAY THERAPY. A REPORT FOR THE YEARS 1937–1942 ON THE MOZELLE SASSOON SUPERVOLTAGE X-RAY THERAPY DEPARTMENT, ST. BARTHOLOMEW'S HOSPITAL. By RALPH PHILLIPS, M.S., M.B., F.R.C.S., D.M.R.E., Sir Halley Stewart Fellow, with the technical assistance of G. S. INNES, B.Sc., A.M.I.E.E., Physicist to the Mozelle Sassoon Department. With a Foreword by The Rt. Hon. The Lord Horder, G.C.V.O., M.D., F.R.C.P. A volume of 142 pages, with 95 illustrations. Published for The Sir Halley Stewart Trust by H. K. Lewis & Co., Ltd., London, 1944. Price 16s. net.

VERNOR M. MOORE, M.D.
1886–1944

In Memoriam

VERNOR M. MOORE, M.D.

1886–1944

Vernor M. Moore, a member of the Radiological Society of North America since 1919, died at his home in Grand Rapids, Mich., Dec. 30, 1944, after a brief illness.

Doctor Moore was born in Freeport, Mich., Feb. 10, 1886. He received his preliminary education at Olivet College and was graduated in medicine from the University of Michigan in 1911. Soon after his graduation he located in Grand Rapids, where he was associated with the late Dr. Richard R. Smith. Doctor Moore's interest in roentgenology led him to devote his entire time to that specialty, and he opened his own offices in 1918.

Doctor Moore led an active life and had a large practice. He was particularly interested in radiation therapy and in chest lesions. That his professional colleagues appreciated his efforts and interest in medicine is indicated by the high regard in which he was held and the important offices he filled in his local and state medical societies. He served as Councilor for the Michigan State Medical Society for ten years, and at the time of his death was President-Elect of the State Medical Society. He was Past-President of the Kent County Medical Society and the Michigan Association of Roentgenologists. He was much interested in anti-tuberculosis activities and was a member of the Board of Directors of his local Anti-Tuberculosis Society for several terms. In addition to membership in the Radiological Society of North America, Doctor Moore was a member of the American Roentgen Ray Society and a diplomate of the American Board of Radiology.

Doctor Moore was a congenial host, and a visit with the Moore family was an event to be eagerly anticipated and recalled with pleasure. His many friends in the medical profession will be grieved to learn of his untimely death. He is survived by his wife, three sons, and a daughter. One of the sons, Gordon, is in military service abroad.

E. R. WITWER, M.D.

RADIOLOGICAL SOCIETIES OF NORTH AMERICA

Editor's Note.—Will secretaries of societies please cooperate by sending information to Howard P. Doub, M.D., Editor, Henry Ford Hospital, Detroit 2, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Building, Syracuse 2, N. Y.

American Roentgen Ray Society.—Secretary, Harold Dabney Kerr, M.D., Iowa City, Iowa.

American College of Radiology.—Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago 11, Ill.

Section on Radiology, American Medical Association.—Secretary, U. V. Portmann, M.D., Cleveland Clinic, Cleveland 6, Ohio.

ARKANSAS

Arkansas Radiological Society.—Secretary, J. S. Wilson, M.D., Monticello. Meets every three months and annually at meeting of State Medical Society.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Earl R. Miller, M.D., University of California Hospital, San Francisco, Calif.

Los Angeles County Medical Association, Radiological Section.—Secretary, Roy W. Johnson, M.D., 1407 South Hope St., Los Angeles. Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Secretary, L. Henry Garland, M.D., 450 Sutter St., San Francisco. Meets annually during meeting of California Medical Association.

San Diego Roentgen Society.—Secretary, Henry L. Jaffe, M.D., Naval Hospital, Balboa Park, Calif. Meets first Wednesday of each month.

San Francisco Radiological Society.—Secretary, Carlton L. Ould, University Hospital, Medical Center, San Francisco 22. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year in Lane Hall, Stanford University Hospital, and second six months in Toland Hall, University of California Hospital.

COLORADO

Denver Radiological Club.—Secretary, A. Page Jackson, Jr., M.D., 304 Republic Bldg., Denver 2. Meetings third Friday of each month at the Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Secretary, Max Climan, M.D., 242 Trumbull St., Hartford 3. Meetings bimonthly, second Thursday.

FLORIDA

Florida Radiological Society.—Secretary-Treasurer, Charles M. Gray, 306 Citizens Bldg., Tampa 2.

GEORGIA

Georgia Radiological Society.—Secretary-Treasurer, James J. Clark, M.D., 478 Peachtree St., N. E., Atlanta 3. Meetings twice annually, in November and at the annual meeting of State Medical Association.

ILLINOIS

Chicago Roentgen Society.—Secretary, Fay H. Squire, M.D., 1753 W. Congress St., Chicago 12. Meets at the Palmer House, second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Frank S. Hussey, M.D., 250 East Superior St., Chicago 11.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, M.D., Methodist Hospital, Indianapolis 7. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Secretary, Arthur W. Erskine, M.D., Suite 326 Higley Building, Iowa City. Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Sydney E. Johnson, 101 W. Chestnut St., Louisville.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society.

Shreveport Radiological Club.—Secretary-Treasurer, R. W. Cooper, 940 Margaret Place. Meetings monthly on the second Wednesday, at offices of members.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Walter L. Kilby, M.D., 101 W. Read St., Baltimore 1. Meets third Tuesday of each month.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit 1. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave., Detroit.

Michigan Association of Roentgenologists.—Secretary-Treasurer, E. M. Shebesta, M.D., 1429 David Whitney Bldg., Detroit. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—Secretary, A. T. Stenstrom, M.D., Minneapolis General Hospital, Minneapolis 26. Meetings quarterly.

MISSOURI

Radiological Society of Greater Kansas City.—Secretary, Arthur B. Smith, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Thursday of each month.

St. Louis Society of Radiologists.—Secretary, Edwin C. Ernst, M.D., 100 Beaumont Medical Bldg. Meets on fourth Wednesday of each month except June, July, August, and September, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—Secretary-Treasurer, Donald H. Breit, M.D., University of Nebraska Hospital, Omaha 5. Meetings third Wednesday of each month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society (Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island).—*Secretary-Treasurer,* George Levene, M.D., Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday at Boston Medical Library.

NEW JERSEY

Radiological Society of New Jersey.—Secretary, H. R. Brindle, M.D., 501 Grand Ave., Asbury Park. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.—Secretary, William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—Secretary-Treasurer, Leo Harrington, M.D., 880 Ocean Ave., Brooklyn 26. Meets fourth Tuesday of every month, October to April.

Buffalo Radiological Society.—Secretary-Treasurer, Joseph S. Gianfranceschi, M.D., 610 Niagara St., Buffalo 1. Meetings second Monday evening each month. October to May, inclusive.

Central New York Roentgen Ray Society.—Secretary-Treasurer, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse 10. Meetings are held in January, May, and October, as called by Executive Committee.

Long Island Radiological Society.—Secretary, Marcus Wiener, M.D., 1430 48th St., Brooklyn 19. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—Secretary, Ramsay Spillman, M.D., 115 E. 61st St., New York 21, N. Y.

Rochester Roentgen-ray Society.—Secretary, Murray P. George, M.D., 260 Crittenden Blvd., Rochester 7. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—Secretary-Treasurer, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meeting with State meeting in May, and meeting in October.

NORTH DAKOTA

North Dakota Radiological Society.—Secretary, L. A. Nash, M.D., St. John's Hospital, Fargo. Meetings by announcement.

OHIO

Ohio Radiological Society.—Secretary, Henry Snow, M.D., 1061 Reibold Bldg., Dayton 2. Next meeting will be held at the time and place of the annual meeting of the Ohio State Medical Association.

Cleveland Radiological Society.—Secretary-Treasurer, Don D. Brannan, M.D., 11311 Shaker Blvd., Cleveland 4. Meetings at 6:30 P.M. on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*Secretary-Treasurer,* Samuel Brown, M.D., 707 Race St., Cincinnati 2. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—Secretary-Treasurer, L. E. Wurster, M.D., 416 Pine St., Williamsport 8. The Society meets annually.

The Philadelphia Roentgen Ray Society.—Secretary, Robert P. Barden, M.D., 3400 Spruce St., Philadelphia 4. Meetings held first Thursday of each month at 8:15 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22d St., Philadelphia.

The Pittsburgh Roentgen Society.—Secretary-Treasurer, Lester M. J. Freedman, M.D., 4800 Friendship Ave., Pittsburgh 24, Pa. Meetings are held on the second Wednesday of each month at 4:30 P.M., from October to June, at the Pittsburgh Academy of Medicine, 322 N. Craig St.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—*Secretary,* A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston 16.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, J. Marsh Frère, M.D., 707 Walnut St., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Dallas-Fort Worth Roentgen Study Club.—Secretary, X. R. Hyde, M.D., Medical Arts Bldg., Fort Worth, Texas. Meetings on third Monday of each month, in Dallas in the odd months and in Fort Worth in the even months.

Texas Radiological Society.—Secretary-Treasurer, Asa E. Seeds, Baylor Hospital, Dallas.

VIRGINIA

Virginia Radiological Society.—Secretary, E. Latané Flanagan, M.D., 215 Medical Arts Bldg., Richmond 19.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Thomas Carlile, M.D., 1115 Terry Ave., Seattle. Meetings fourth Monday of each month, October through May, at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—Secretary-Treasurer, C. A. H. Fortier, M.D., 231 W. Wisconsin Ave., Milwaukee 3. Meets monthly on second Monday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russell F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison 6, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

CANADA

La Société Canadienne-Française d'Electrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meetings are held the third Saturday of each month, generally at the Radium Institute, 4120 East Ontario Street, Montreal; sometimes, at homes of members.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meetings are held monthly.

ABSTRACTS OF CURRENT LITERATURE

ROENTGEN DIAGNOSIS

The Head and Neck

The Chest

The Digestive System

The Peritoneum

The Skeletal System

Gynecology and Obstetrics

The Genito-Urinary Tract

The Blood Vessels

Miscellaneous

RADIOTHERAPY

Neoplasms

Non-Neoplastic Conditions

Effects of Radiation

ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Non-Secreting Cysts of the Maxillary Sinuses, with Special Reference to the Roentgen Aspects and Diagnosis of the Large Types. Jack W. Grossman and Harold D. Waltz. Am. J. Roentgenol. **52:** 136–144, August 1944.

In a series of 80 consecutive roentgen examinations of the sinuses, 13 cases of probable antral cysts were found. Six of these were of the non-secreting type, filling the entire antrum.

The classification of cysts of the maxillary sinus given by Lindsay (Laryngoscope **52:** 84, 1942) is quoted, as follows:

1. Benign cysts arising from the jaw or teeth
   - (*a*) Follicular (dentigerous) cyst
   - (*b*) Radicular (root cyst, dental cyst)
   - (*c*) Median anterior maxillary cyst
2. Benign cysts arising from the sinus mucosa
   - (*a*) Secreting cysts
     - Gland or mucous cysts
     - Mucocele
   - (*b*) Non-secreting cysts of sinus mucosa

Of these various types, the most common is the non-secreting cyst. This varies in size and location but tends eventually to gravitate downward to the most dependent portion of the antrum. It arises in the subepithelial connective tissue as a result of fluid retention in the connective-tissue spaces. It probably is caused by the action of bacterial toxins resulting from infection producing damage of the capillary walls and altering their permeability.

Diagnosis is dependent largely upon roentgen examination, since clinical signs and symptoms may be absent and there may be little interference with transillumination. Small cysts are readily recognized by the contrast afforded by the air around them. They differ from polyps in that the lining membrane is usually normal. Large cysts may cause complete opacity of the antrum. Of significance in diagnosis is the fact that the shadow does not change in the upright and recumbent projections. Also, there is no alteration in the bony wall to indicate infection, pressure atrophy, or invasion. These findings aid in differentiation between large cysts and acute inflammatory lesions, polyps, mucocele, and carcinoma. The absence of significant clinical symptoms (except toothache when the cyst is under pressure) and the knowledge that the sinus transilluminates well make the diagnosis more certain.

L. W. PAUL, M.D.

Hyperparathyroidism, with Failure to Recalcify After Removal of Parathyroid Adenoma (A Case Report). Charles P. Voltz and Katharine Smull. Ann. Int. Med. **21:** 329–332, August 1944.

A parathyroid adenoma was removed from a patient with a history of repeated pathological fractures and roentgen evidence of generalized skeletal decalcification associated with cystic and fibrotic bone changes. Five years later the roentgen picture of decalcification was unchanged, in spite of the fact that there was no evidence of recurrent hyperparathyroidism. The authors attribute this to arrested osteoblastic activity.

THE CHEST

The Blood Supply of the Sternum. I. X-Ray Studies of Injected Sternums Showing Venous Return. Philip Pizzolato. New Orleans M. & S. J. **97:** 71–72, August 1944.

Investigations of the blood supply of the sternum were carried out with 5 per cent ferric ferrocyanide and lead chromate as blue and yellow pigments, in a 20 per cent vinylite solution in acetone. The former is excellent for translucent preparations, while the latter is more opaque to the x-rays. In these studies, 1 to 5 c.c. of the mixture was injected in the manubrium and in various portions of the body of the sternum. The medium flowed with slight difficulty and soon entered the sternal tributaries of the mammary vein. The bones were x-rayed and then cleared in oil of wintergreen. The author found no sternum in which large blood vessels ran through the body, as reported by Tocantins (Proc. Soc. Exper. Biol. & Med. **45:** 202, 1940); in the adult he observed a few large branches anastomosing at the lower portion of the sternum, and in children, small branches connecting one center of ossification with another.

Agenesis of the Lung. Anibal Roberto Valle and Evarts A. Graham. J. Thoracic Surg. **13:** 345–356, August 1944.

A review of the literature shows 38 proved cases of agenesis of the lung. All of these cases are abstracted briefly in tabular form, and 2 additional examples are presented. One of the patients, a forty-one-year-old woman, was explored and the diagnosis verified. In the second patient, a five-year-old boy, the diagnosis was not proved. In each case it was the left lung which was absent, an observation which is twice as common as absence of the right lung. The x-rays showed a uniform opacity of the left lung field with a high diaphragm, shift of the mediastinum to the left, and narrowed intercostal spaces. Bronchography revealed a short left main bronchus with complete occlusion. Bronchoscopy showed the bronchus to end abruptly with a smooth mucosa and no suggestion of a tumor.

There are usually no acutely distressing symptoms in agenesis of the lung, but dyspnea, cyanosis, and harsh breathing are common, and young patients do not develop as well or as rapidly as normal children.

[Deweese and Howard (Radiology **42:** 389, April 1944) were able to find in the literature 43 cases of congenital absence of the lung, to which they added another.—Ed.] H. O. PETERSON, M.D.

Closed Intrapleural Pneumonolysis. C. G. Bayliss. M. J. Australia **2:** 129–137, Aug. 5, 1944.

The suitability of a patient for intrapleural pneumonolysis rests primarily on the roentgen examination, supplemented by fluoroscopic observation. In the author's experience, the preoperative opinion that a patient was unsuitable for pneumonolysis was seldom incorrect; while in many persons in whom it was hoped to perform a complete pneumonolysis this could be only partially accomplished, if at all.

This report is based on 143 operations on 115 patients. In 65 cases complete pneumonolysis was carried out

(*i.e.*, all adhesions preventing effective collapse of the lung were freed), and in 59 of this group relaxation of the lung was satisfactory. In 35 patients an incomplete pneumonolysis was done, and in 11 of these relaxation was satisfactory. The operation was thus of value in 70 cases.

In 10 of the 115 patients major complications developed. Severe hemorrhage occurred in 3 cases, and empyema in 7, including 1 of the 3 with hemorrhage. In 5 the empyema was proved to be tuberculous, while in the remaining 2 it was believed to be so. In 4 instances the empyema was secondary to a spontaneous pneumothorax. Spontaneous pneumothorax also developed in 1 additional patient. A subsequent obliterative pleuritis occurred in several cases at varying periods after operation.

The author believes that practically all tuberculous patients undergoing collapse therapy should be given the benefit of thoracoscopic examination and, when possible, pneumonolysis, as the results are better both from the point of view of complications and control of the pulmonary lesion. ELLWOOD W. GODFREY, M.D.

Syphilis and Pulmonary Tuberculosis in the Negro. Reuben Hoffman and George G. Adams. Am. Rev. Tuberc. **50:** 85–95, August 1944.

In an attempt to determine whether the presence of syphilis in the Negro influences the course of pulmonary tuberculosis, comparison was made of a group of adult Negroes who had pulmonary tuberculosis and syphilis with a group who had tuberculosis alone. The material consisted of 1,705 consecutive sanatorium admissions. Of the 1,705 patients, 507 had positive serologic tests. The percentages of syphilis in the minimal, moderately advanced, and far advanced stages of tuberculosis were fairly comparable, being 24.7 per cent, 29.2 per cent, and 31.1 per cent, respectively. No significant differences were noted in the pathologic types of the tuberculous disease in the two groups and the death rates were similar. The conclusion is reached that the presence of syphilis does not alter the course of pulmonary tuberculosis.

Concerning the question of antisyphilitic treatment in patients with tuberculosis, it is recommended that such treatment be given only when the prognosis for the latter disease is good. Two conditions offer exceptions to this rule, *i.e.*, pregnancy and the presence of syphilis in an infectious stage. These require antisyphilitic therapy regardless of the outcome of the tuberculosis.

L. W. PAUL, M.D.

Postoperative Emphysematous Bullae Following Lung Abscess. Waldo R. Oechsli. Am. J. Roentgenol. **52:** 145–148, August 1944.

A case is reported of a patient with a lung abscess which was drained surgically, following which there was a clinical cure. Postoperative roentgen studies, including planigrams, revealed persisting shadows, which were interpreted as emphysematous bullae, in the region of the previous abscess. The walls of these rarefactions were thin, being of uniform thickness, and there was no associated density in the adjacent lung. The case is reported as another residual complication following lung abscess. Such bullae, if seen for the first time without a knowledge of the preceding infection, might be diagnosed as congenital cystic disease.

L. W. PAUL, M.D.

Benign Pulmonary Changes in Arc-Welders: Arc-Welder's Siderosis. J. A. Groh. Ohio State M. J. **40:** 732–735, August 1944.

Pulmonary changes demonstrated roentgenographically in arc-welders' chests have been observed since 1936. They were believed to occur only when welding was done in closely confined and poorly ventilated spaces. The author studied 83 of 125 welders in an industrial plant providing screening from ultraviolet radiation and suction ventilation in a large open building. These precautions were considered adequate protection.

After exclusion of all with histories of exposure to silica dusts, 71 per cent of the welders were found to have fine nodulations evenly distributed over the lung fields. The individual lesions varied from 1 to 3 mm. in diameter, were sharply defined, roughly rounded, and more numerous near the hila. The lungs were normal except for the nodulations. There was no evidence of enlarged hilar nodes, increased fibrous tissue, inflammatory changes, thickened pleurae or septa, or adhesions. These points are important in differentiating from silicosis. Miliary tuberculosis must be ruled out by clinical findings.

The cases were divided, according to extent of involvement, into minimal and extensive groups. Fifty-six per cent of the positive cases showed extensive involvement. On the average, those showing no involvement had been welding 6.7 years; those with minimal involvement 8.5 years; those with extensive involvement 9.2 years. Six non-welders working as welders' helpers showed no involvement, indicating that close approximation to the fumes and inadequate ventilation are important etiologic factors.

This series represents a higher incidence than ever previously reported, in spite of the fact that these men did not work in closely confined, supposedly ill-ventilated places. No cases of active tuberculosis were found; 5 men showed fibrotic or calcified lesions with no reactivation though they had been engaged in welding from five to ten years. The evidence cited here and elsewhere shows that arc-welder's siderosis does not predispose to tuberculosis or reactivate old tuberculous lesions.

The pathological changes were described by Enzer and Sander (J. Indust. Hyg. & Toxicol. **20:** 333–350, May 1938) as deposits of iron oxide along the pulmonary lymph channels and in the regional nodes without any scarring or fibrosis. These undoubtedly account for the minute nodulations seen radiographically with absence of secondary changes.

Some men who had been welding as long as sixteen years showed no changes. This is explained by variations in ventilation and individual differences, such as a tendency toward mouth breathing and greater or less efficiency of filtration of the upper air passages. None of those showing siderosis had any physical disability, nor was there any evidence to indicate that future disability directly traceable to the siderosis might be expected. This should not encourage carelessness in exposure to welding fumes, however. Rather, when cases of siderosis are discovered, every precaution should be taken to insure adequate ventilation. The author believes that arc-welder's siderosis should not be considered a serious debilitating disease, since such a stigma is easily applied and quickly disseminated but, once accepted, is slowly repudiated.

BERNARD S. KALAYJIAN, M.D.

Mediastinal Herniation in Artificial Pneumothorax. Case Report of Bilateral Mediastinal Herniation in Bilateral Pneumothorax and Herniation of Extreme Size and Unusual Type. I. D. Bobrowitz. Am. Rev. Tuberc. **50:** 150–159, August 1944.

Mediastinal hernia is not infrequently observed during artificial pneumothorax and usually causes no untoward symptoms. It occurs most commonly in the anterior mediastinum, since this is the weakest point. A case is reported in which, following a bilateral pneumothorax, bilateral mediastinal herniation developed. A left-sided pneumothorax was followed by an extensive herniation to the right, which extended across the mid-line to reach the right lateral chest wall and raised the question of a spontaneous pneumothorax on that side. The correct diagnosis was established by the injection of saline into the left pleural cavity and demonstration of a fluid level on the right. When a right pneumothorax was instituted, a similar herniation developed to the left, with the right-sided herniation persisting. Both herniations traversed the anterior mediastinal space. No symptoms were produced by these massive herniations. L. A. PAUL, M.D.

THE DIGESTIVE SYSTEM

Benign Tumors of the Stomach. Edward B. Dewey. Am. J. Surg. **65:** 233–237, August 1944.

That benign tumors of the stomach are relatively rare is attested by the fact that during the past twenty years only 5 patients with this type of tumor have been admitted to the Huntington Memorial Hospital, Pasadena. Malignant change is frequent and had occurred in 2 of the 4 myomas in this series; in the fifth case the tumor was a benign papilloma.

Anemia, dyspepsia, and vomiting are frequently associated with benign gastric neoplasms. In the diagnosis, roentgenoscopy and gastroscopic examination are most important. The roentgen picture is characteristic, showing smooth, punched-out filling defects, most easily seen in the partially filled stomach. Peristalsis is only slightly interfered with, and surface ulcers are readily demonstrable. Rugae commonly are normal to the base of the tumor. Gastroscopy is of value especially in viewing the smaller tumors. Large tumors, however, may be seen only in part, and in such cases roentgen examination is more trustworthy.

Surgical treatment of benign tumors of the stomach is generally satisfactory, and the mortality is low.

Giardiasis with Unusual Findings. P. B. Welch. Gastroenterology **3:** 98–102, August 1944

Twenty-nine cases of giardiasis are presented, including 13 previously reported from a clinical point of view (Welch: Am. J. Digest. Dis. **10:** 52, 1943). All of the original 13 cases showed roentgen evidence of functional and/or anatomic changes in the duodenum, duodenal cap, pylorus, and prepyloric area of the stomach. Two of the patients had duodenal ulcers, which, of course, were not ascribed to the giardiasis. There were also 2 cases of pyloric hypertrophy, one of which was definitely aggravated by the associated giardial infestation. This leaves 10 cases, or 77 per cent, with roentgen changes in the peptic area attributable to giardiasis.

Of the 16 more recent cases, 8 were in adults and 8 in children from three to seventeen years of age. The 8 adults all presented abdominal symptoms. In the children, Giardiae were found on routine stool examinations; abdominal symptoms were present in only 3. Roentgen changes were found in the 7 adults examined. Duodenal ulcer was present in one of these, and gastric ulcer in another. Since in these cases the associated changes could not be ascribed to giardiasis alone, the incidence of positive findings is given as 5 out of 7, or 71 per cent, for the adult group. X-ray examination showed changes in the peptic area in 6 of the 8 children (75 per cent). In 4 of these no abdominal symptoms were present. Thus 11 of the 15 patients examined roentgenographically, or 73 per cent, showed evidence of anatomic or functional changes in the peptic area attributable to the parasite.

Of the combined series of 28 cases examined roentgenographically, findings attributable to giardiasis were present in 21 (75 per cent). Signs of duodenal irritation were found in 50 per cent of 24 cases reported by Spears (Rev. Gastroenterol. **6:** 512, 1939).

The eosinophil count varied from 4 to 13 per cent in 22 of the author's 29 cases (approximately 76 per cent). This count was found to have returned to normal in 16 of the 21 patients re-examined after treatment with atabrine. A relatively high white blood count, 10,000 or over, was encountered in 15 cases, with a drop after atabrine therapy in 11.

Management and Prognosis of Megacolon (Hirschsprung's Disease): Review of Twenty-four Cases. K. S. Grimson, H. N. Vandegrift, and H. M. Dratz. Am. J. Dis. Child. **68:** 102–115, August 1944.

A study of the 24 cases of Hirschsprung's disease seen in the Duke Clinic, since its opening in 1930, suggests a definite plan of treatment determined by the anatomic distribution of the megacolon. The cases are divided into 3 groups: Group I, 12 patients, with uniform involvement of the entire colon terminating in a dilated or easily dilatable rectum; Group II, 7 patients, with uniform dilatation of the proximal colon terminating in a normal bowel segment, usually in the sigmoid, and a normal rectum; Group III, 5 patients, with enormous enlargement of the sigmoid or the sigmoid and descending colon with or without some enlargement of the proximal segments of the colon and the rectum. The case histories are given and numerous roentgenograms are reproduced.

Medical management consisting chiefly of diet, laxatives, enemas, and parasympathomimetics is advised in treatment of Group I patients as long as adequate nutrition can be maintained and persistent distention avoided. Sympathectomy is of questionable value, as it does not alter the gross pathologic condition and, by interrupting the visceral sensory pathways, may permit negligence on the part of the patient, with resultant impaction. Since, according to the literature, segmental resection is often followed by recurrent impactions proximal to the anastomosis, resection, when necessary, should start at the ileocecal junction, with removal of the entire megacolon. Of the authors' 12 patients in this group, 8 were living and evacuating the colon readily at an average age of ten years. One patient, aged 24, died three years following a sympathectomy. One patient, aged 6, was having moderately severe trouble at the time of the report; one required surgical reduction of a volvulus at the age of 20; and one had a reduction of a sigmoid volvulus at the age of 59 with a recurrence in three months, at which time sigmoidectomy was performed.

Group II has the gravest prognosis because of the ease with which intestinal obstruction may develop. Of the 7 patients in this group, 4 receiving conventional treatment died, 2 at the age of 15 months, 1 at 9 years, and 1 at 17 years. The remaining 3 had equally severe symptoms and as enormous colons as the others. They are living and well following complete resections of the megacolon at the ages of 2, 11, and 21 years, with anastomoses between the ileum and the normal sigmoid stump. Preliminary colostomy may be necessary in severe acute obstruction.

The 5 patients of Group III, having dilatation of the sigmoid, are all living at an average age of 16 years, 2 free from symptoms and 3 with moderately severe symptoms. Protracted medical management is considered justified in this group, and it is believed that in patients with normal segments of sigmoid colon and normal rectums these structures may become progressively dilated and accomplish massive evacuation of impactions.

Repeated barium roentgen studies are advocated to determine the progress of the condition and as an aid in determining the choice between protracted medical treatment and resection. Roentgenography is of particular importance following decompression of the bowel, since a normal rectum or sigmoid may appear enlarged during delivery of an impaction.

LESTER M. J. FREEDMAN, M.D.

Treatment of Large Bowel Obstruction. Transverse Colostomy—Incidence of Incompetency of Ileocecal Valve: Experience at the University of Minnesota Hospitals. Clarence Dennis. Surgery **15:** 713–734, May 1944.

The most common cause of acute obstruction of the colon is a carcinomatous stricture. According to figures from the Mayo Clinic, two-thirds of the colic cancers causing obstruction involve the descending, sigmoid, or rectosigmoid colon, while only one in seven lies cephalad to the splenic flexure. Extracolic neoplasms and pelvic and sigmoid inflammatory lesions rank second in etiologic importance, with volvulus of the sigmoid a poor third, at least in America. Partial obstruction is much more common than complete, but it is not easy to evaluate statistically and is not considered here.

The low position of the obstructing lesion in the intestinal tract usually permits absorption by the bowel higher up of much of the food, water, and salt taken by mouth, and patients are therefore relatively free from hypochloremia, uremia, and severe dehydration. A factor further tending to inhibit chemical imbalance is the frequent absence of severe vomiting, commonly attributed to competency of the ileocecal valve. A competent ileocecal valve is also of significance since it renders colic occlusion a type of "closed-loop" obstruction.

Early in left colic obstruction, distention may occur just proximal to the lesion, and, since peristaltic rushes are far less frequent here than in the ileum, cramps and borborygmi may be present at intervals of from ten to thirty minutes or longer. Later, as the entire proximal colon becomes distended, this interval is reduced to three to ten minutes, corresponding to the interval between major contraction waves in the ileum. It may be shorter if distention extends higher in the small bowel or, later in the process, cramps may be absent altogether.

Scout films of the abdomen regularly show distention of the colon from the cecum to the point of obstruction. Gas due to stasis is frequently demonstrable in the terminal ileum, and distention of the small bowel may occasionally be present. Barium enema studies not only may fail to reveal the site of obstruction, but may convert a partial obstruction into a complete one.

Small bowel obstruction is differentiated by the almost constant presence of vomiting, often of fecal character, by the consistent occurrence of cramps at intervals of less than ten minutes, and the ladder-like arrangement of loops of small bowel usually apparent on the scout film. Infrequently, colic obstruction, especially if situated in the right colon, may simulate small bowel obstruction in all these respects.

Preoperative diagnosis of volvulus of the sigmoid colon is of great practical importance, for it is fundamentally a greater threat to the blood supply of the sigmoid loop than simple obstruction is to that of the cecum. In volvulus there is usually a history of constipation, and the condition is particularly apt to occur in patients with megacolon. There is likely to be a history of previous attacks and recent sudden onset of abdominal pain with increasing distention and failure to pass flatus. Roentgen pictures usually show a single loop far more enlarged than others, with a tendency to extend up to the right upper quadrant and even, at times, to overlie the liver.

In simple obstructions, experience has shown that preliminary decompression reduces the risk of resection by more than half. For this purpose, transverse colostomy with a transverse incision, preferably across the right rectus muscle between the umbilicus and the xiphoid, as described by Wangensteen, is recommended. When the lesion lies in the right colon, insertion of a catheter into the cecum by way of the appendix or the terminal ileum must be performed, cecostomy being reserved for only the rarest occasions. Volvulus of the sigmoid colon is potentially a strangulating obstruction and, as such, demands immediate detorsion as well as decompression of the colon proximally.

The author reports a series of 54 cases of colic obstruction seen over a period of six years. Of these, 35 were due to carcinoma of the colon or rectum. The incidence of complete obstruction in cancer of the colon during this same time was 9.5 per cent. Twenty-eight of the 35 patients with carcinoma had obstruction of the left colon, and 6 in the region of the hepatic flexure. One had a lesion in the transverse colon, involving the ileum as well. Among other causes of obstruction in the series were neoplasms elsewhere in the pelvis involving the colon secondarily, pelvic inflammatory lesions, volvulus of the sigmoid, and impaction of feces following a barium meal. In 9 cases an incomplete obstruction became complete following the introduction of a barium mixture either by mouth or as an enema.

Transverse colostomy was done in 38 cases of acute left colic obstruction, of which 25 were due to intrinsic cancer. Among the 38 cases there were but 3 deaths, a mortality rate of 7.9 per cent. None of the deaths, however, was directly attributable to the performance of the colostomy. Inguinal colostomy was done in three low-lying obstructions, with no deaths.

There were 6 cases of right colic obstruction due to carcinoma. Three of the patients were treated by terminal double-barreled ileostomy with insertion of a catheter through the ileum and into the cecum; an appendicostomy was done in one, and decompression

by Miller-Abbott tube in 2, each of these last being subjected three days thereafter to hemicolectomy with primary end-to-end ileotransversostomy. There were 2 deaths in this series.

The author includes some "observations on the incidence of vomiting and of small bowel distention in acute colic obstruction." He quotes Wangensteen as pointing out that fecal emesis usually indicates small bowel obstruction, while in the majority of instances of colic obstruction the ileocecal valve prevents reflux into the ileum and vomiting of fecal character. Competency of the ileocecal valve has been adopted by many radiologists as an aid in the diagnosis of colic obstruction, absence of gas visible in the ileum confirming this impression. In a little more than two-thirds of the author's group, the films presented some definite evidence of gas in the ileum, about one in three presented real ileac distention, and in fewer than 8 per cent was the small bowel distention more striking than the distention of the colon. About one-third of the patients who vomited showed no intra-ileac gas on the films. This vomiting, therefore, must be explicable as reflex in nature.

It is apparent from the author's observations that competency of the ileocecal valve is usually but by no means invariably present in obstructive lesions of the colon. There was definite regurgitation into the small bowel in about one-third of his series, and vomiting occurred in about 12 per cent. The presence of vomiting, therefore, even if persistent and fecal in character, should not cause the examiner to overlook entirely the possibility of large bowel obstruction.

J. E. WHITELEATHER, M.D.

Difficulties in the Roentgenological Examination of the Biliary Tract. Adrian J. Bengolea, Carlos Velasco Suarez, and Alfredo Negri. Am. J. Roentgenol. **52:** 149–164, August 1944.

Cholangiography is a useful procedure in the postoperative study of the bile ducts not only for the demonstration of calculi but in certain other physiologic and pathologic disturbances of the biliary tract. In this latter connection the method is not infallible and errors of interpretation may be made. The present report discusses some of these and methods to avoid them.

Calculi may be obscured if they are small and covered with the opaque medium or if complete filling has not been obtained. When the common or one of the hepatic ducts is obstructed, the margin of the opaque shadow will be sharply outlined and concave. The calculus itself may not be visible, but its presence may be suspected by other alterations, such as dilatation of the biliary tree, failure of passage of the medium into the duodenum, or failure to outline one or both hepatic ducts. Injection of air bubbles may cause false images. Careful technic, repeated roentgenograms, and the use of sufficient contrast medium help to avoid these mistakes.

The second part of the report is given over to a consideration of the use and value of cholangiography in studying biliary tract physiopathology. It is believed that too much information should not be expected from this type of roentgen study. Filling of the pancreatic duct has been reported as evidence of contraction of the sphincter of Oddi. The authors believe that there are other reasons, including the normal mucosal folds in the ampulla of Vater, which may act as valves, and, even more important, hyperplasia of the mucosa in the ampulla. In all of these so-called functional disturbances, where the surgeon is unable at operation to find any obvious cause for obstruction and jaundice, care should be exercised in the interpretation of subsequent cholangiograms, since many of these functional disturbances are poorly understood and roentgen examination alone may not be sufficient to establish a diagnosis.

L. W. PAUL, M.D.

Calcification of the Pancreas. Case Report. Charles M. Graney and Robert H. Reddick. Am. J. Surg. **65:** 271–275, August 1944.

There are two distinct types of pancreatic calculi: (1) true stones found in the pancreatic ducts, corresponding to stones in the gall ducts or ureters; (2) false stones or calcification of the gland, in which the stones occur chiefly in the parenchyma and less often in the ducts. A case of the latter type is presented.

THE PERITONEUM

Roentgen Features of Chronic Tuberculous Peritonitis. James J. McCort. Arch. Surg. **49:** 91–99, August 1944.

Peritoneal infection with the tubercle bacillus may be acute or chronic. The acute type may take the form of a miliary tuberculous peritonitis as a part of generalized miliary tuberculosis, or a localized peritonitis with involvement of a few lymph nodes and the adjacent peritoneum. This second type, through breakdown of the tubercles in a person with lowered resistance, may lead to a chronic generalized tuberculous peritonitis. The result is a diffuse adhesive process involving the peritoneal surfaces. This adhesive tendency leads to features which, while not pathognomonic, are strongly suggestive of the condition. These diagnostic points are: (1) a low-grade ileus with variable amounts of intra-abdominal fluid, demonstrable on the plain roentgenogram; (2) fixation of the entire large bowel, demonstrable with the aid of a barium enema, especially by absence of change of position on evacuation (actual adhesions can occasionally be shown); (3) abnormally rapid passage of barium through the small intestine, following a small-intestinal enema, with binding together of loops and shortening of the bowel. The intervals between barium-filled loops tend to be widened and irregular, with abnormal segmentation.

Six illustrative cases are recorded, in 3 of which the employment of the criteria noted led to a correct preoperative diagnosis. LEWIS G. JACOBS, M.D.

THE SKELETAL SYSTEM

Osteogenesis Imperfecta and Osteopsathyrosis. A Contribution to the Study of Their Identity and Their Pathogenesis. S. Rosenbaum. J. Pediat. **25:** 161–167, August 1944.

The question of whether the "early type" of fragilitas ossium with intrauterine fractures (osteogenesis imperfecta, type Vrolik) is essentially different from the "late type" with only postnatal fractures (osteopsathyrosis, type Lobstein) is as yet unsolved. The pathogenesis is likewise indeterminate. Glanzmann (Schweiz. med. Wchnschr. **66:** 1122, 1936. Abst. in Radiology **28:** 639, 1937) favors the duality of the two syndromes. In his opinion the "early type" is not hereditary; the limbs are shortened (micromelia), the cranium consists only of small islands of bony structure,

the calcium level in the serum is elevated, the concentration of serum inorganic phosphorus is at the upper limits of normal, and the total duration of life rarely, if ever, exceeds four years. He regards the "late type" as a qualitatively different disease in that the body proportions are normal; the bony deformities are found in the middle of the shafts, the cranium is unyielding, the calcium level in the serum is normal, serum inorganic phosphorus is low, and life expectancy is not curtailed. Funk (Schweiz. med. Wchnschr. **70:** 473, 1940. Abst. in Radiology **37:** 123, 1941) states that cases of osteopsathyrosis (Lobstein) never occur with cases of osteogenesis imperfecta (Vrolik) in the same family.

A number of cases are presented here to show the relationship between the two disease syndromes. Two infants who in highest likelihood suffered from intrauterine fractures and exhibited the other characteristics of osteogenesis imperfecta (Vrolik) came from a typical Lobstein family, in which three previous cases of fragilitas ossium are known to have occurred—in the mother, an aunt, and the great grandmother. All of the fractures sustained by these women were of postnatal origin. Both children survived their fifth year.

Another case represents a typical example of the Lobstein syndrome. The value of the serum calcium, however, was subnormal when first measured (when the patient was 7 1/2 years of age) and not until she was 11 1/2 did it reach normal. The serum inorganic phosphorus was at first elevated, later normal, or slightly below normal. This patient's brother sustained a fracture of the femur when fourteen days old and a fracture of the forearm when nine years old. His sclerae were blue and the tympanic membranes blue-gray.

The fifth case is that of a male child who at the age of twenty-two months suffered from a typhoidal meningoencephalitis and subsequently exhibited the clinical picture of osteopsathyrosis with decalcification of the skeleton, fractures of the femora, and deformities of the ribs and vertebral bodies. On roentgen examination of the cranium, signs of increased intracranial pressure were found. Osteosclerotic proliferation of the margins of the vertebral bodies was observed.

On the basis of his observations, the author concludes that osteogenesis imperfecta of the Vrolik type and osteopsathyrosis of the Lobstein type are different manifestations of a single disease. The pathogenetic relationship between cerebral disease and osteoporosis is discussed. As in the fifth case, osteopsathyrosis may develop after cerebral disorders and presumably in response to them. The suggestion is made that an alteration in the region of the hypophysis or infundibulum may provisionally be regarded as the origin of skeletal abnormality both in typical cases of osteopsathyrosis (Lobstein) and in osteogenesis imperfecta (Vrolik). Consonant with this hypothesis is the well known circumstance that fresh spontaneous fractures do not occur in osteopsathyrosis after puberty. Acting on this theory, the author treated cases of osteopsathyrosis with extracts of anterior pituitary and found the results encouraging. He recommends its use in the treatment of this condition.

Roentgenographic Studies of the Cervical Spine. Lee A. Hadley. Am. J. Roentgenol. **52:** 173–195, August 1944.

Studies of the cervical spine in the lateral projection in extremes of flexion and extension and in 45° oblique views give valuable information as to the mobility of the vertebral segments, the condition of the disks, and the intervertebral foramina in a variety of pathological conditions. The author describes and illustrates the normal appearances in these various projections and discusses some of the lesions encountered in this region.

Traumatic lesions to be searched for include partial bilateral subluxations and unilateral subluxation. Spontaneous subluxation of the atlas is found, as a rule, in children complaining of stiff painful neck, usually of sudden onset. Lateral roentgenograms reveal a space between the anterior arch of the atlas and the odontoid and show the posterior arch of the atlas well forward on those below. Other conditions discussed include disk degeneration, spondylitis deformans, and foramen encroachment. Encroachment on the foramina may occur in at least six ways. It may be (1) physiological, due to dorsal extension, or may be the result (2) of trauma, as in fracture or, rarely, a posterior subluxation, (3) of arthritic processes with bony exostoses projecting into the foramina, (4) of thinning of the intervertebral disk, allowing the bodies to come closer together, (5) of fibrous hyperplasia of the posterior joint capsule, or (6) of a tumor.

Congenital anomalies of the cervical spine include various types of fusion such as the Klippel-Feil syndrome and platybasia. The latter may be congenital, with varying degrees of fusion between the atlas and the occiput, or acquired as the result of softening of the base of the skull, as seen in Paget's disease, etc.

In connection with platybasia it is pointed out that the area about the foramen magnum may assume certain features resembling a vertebral segment, the occipital vertebra. The foramen magnum may be distorted as a result of this anomaly and surgical treatment may be in order. In these cases the atlas is normal but the bony structures around the foramen magnum suggest a partially formed, fused vertebral segment.

L. W. PAUL, M.D.

Effect of Increased Intraspinal Pressure on the Movement of Iodized Oil within the Spinal Canal. Bernard S. Epstein. Am. J. Roentgenol. **52:** 196–199, August 1944.

During roentgenoscopy in the course of iodized oil myelography the authors noticed that the oil column rose in the lumbar canal when the patient coughed or strained, as at stool. The ascent of the oil column usually was rapid, reaching its maximum in a few seconds. This is believed to be due to an increase in the amount of blood in the venous plexus between the dura and the walls of the spinal column. This procedure is advocated as a routine during myelography, as small indentations on the oil column may be brought into bolder relief and the axillary pouches above the area under immediate scrutiny often can be filled.

L. W. PAUL, M.D.

Pain and Disability of Shoulder and Arm Due to Herniation of the Nucleus Pulposus of Cervical Intervertebral Disks. Jost J. Michelsen and Wm. J. Mixter. New England J. Med. **231:** 279–287, Aug. 24, 1944.

The prominent place held by lumbar disk lesions somewhat beclouds the fact that the condition can occur at other spinal levels. This article reviews the literature of cervical disk lesions and presents 8 cases.

The patient with a cervical disk lesion usually complains of pain and paresthesias over the shoulder and down the arm. In most cases there is a history of injury, although the pain and paresthesia may not appear until some time later. The pain is usually described as stabbing, shooting, sharp, or acute. Rarely is there pain over the spine, although a spinous process may be sensitive to pressure. Sneezing and coughing may accentuate the pain. Muscle weakness may be present. Spinal fluid protein is elevated or at a high normal.

Roentgen examination of the spine may show a narrowed interspace, absence of cervical lordosis, or hypertrophic change. The lesion may be demonstrated by lipiodol examination of the spinal canal.

The dermatomes of the upper extremity do not seem to be worked out sufficiently accurately to make an exact identification of the level of injury, but they are of some help. More extensive experience with this lesion will doubtless be a means of more accurate definition of the dermatomes.

Operative procedures adequately relieve the disability. JOHN B. MCANENY, M.D.

Pneumoradiography of the Knee Joint. Francis Blonek and Joseph Wolf. J. Iowa M. Soc. **34:** 354–360, August 1944.

Three methods have been employed for demonstrating intra-articular structures of the knee joint with the aid of contrast media: (1) like the negative contrast with substances giving a less dense shadow than body tissue, such as air, oxygen, nitrogen, carbon dioxide, and helium; (2) positive contrast, with radiopaque substances giving a more dense shadow than body tissue, as solutions of metal salts, various compounds of iodized oil, or watery solutions of iodides; (3) a combination of the two, or the double contrast method. The authors' method of pneumoradiography falls in the last classification. After injection of an opaque fluid and oxygen inflation, three antero-posterior films are taken with the patient supine and in right and left lateral positions and the x-ray beam in the horizontal position. Since each time the gas collects at the highest level, different parts of the joint are thus outlined. Additional lateral and, if necessary, oblique views will show further details.

In a pneumoroentgenogram of the knee joint, the following structures besides the bones will be visible: (1) the hyaline cartilages of the femur, tibia, and posterior aspect of the patella, appearing as a slightly grayish layer, coating the articular planes of the bones and outlined against the joint cavity by a fine dense line formed by the thin film of the opaque fluid; (2) both menisci and their attachment to the fibrous capsule and, on lateral views, to the transverse ligament; (3) the attachment of both cruciate ligaments to the intercondyloid eminences of the tibia (oblique views may show some of their length); (4) the synovial membrane and joint cavity, the former represented by a thin line of varying density produced by the coating opaque fluid (in the pouches often larger amounts of contrast material are deposited, which has the undesirable effect of obscuring details); (5) the infrapatellar fat pad, which in plain films is seen as an area of decreased density and in pneumoroentgenograms appears inversely as increased density contrasting with the gas-filled transparent anterior compartment; (6) the plicae alares, if pathologically condensed and thus demarcated against the gas-filled joint space; (7) the pouches of the joint cavity, filled with gas and distinctly demonstrated as transparent dark areas.

Dislocation of the Knee Joint. A Report of Two Cases. James Warren Sever. New England J. Med. **231:** 318–319, Aug. 31, 1944.

Two case reports of dislocation of the knee are presented because of the rarity of this condition. Anterior dislocation is the most common type, accounting for 40 per cent of all knee dislocations; posterior dislocation accounts for 20 per cent; lateral dislocation for 20 per cent; and medial for about 7 per cent (13 per cent are unaccounted for).

In one of the reported cases the dislocation was anterior; reduction was accomplished without great difficulty and a good result was obtained. The second patient had a posterior dislocation complicated by fracture of the upper tibia and compounding. A good result followed.

Injury to the nerves and vascular structures may be expected with these injuries, and make treatment more difficult. JOHN B. MCANENY, M.D.

Aseptic Necrosis of the Head of the Femur Following Traumatic Dislocation of the Hip. S. Kleinberg. Arch. Surg. **49:** 104–108, August 1944.

This report calls attention to the fact that traumatic dislocation of the hip may occur without rupture of the ligamentum teres and records an instance of typical aseptic necrosis of the femoral head in spite of an intact and normally vascularized ligamentum teres.

The patient was a man of 20 who had suffered a simple dislocation of the right hip, immediately reduced, four years before. He was allowed to walk after two weeks. A year later a painful limp developed, which was gradually progressive. Examination showed all motions of the hip to be limited and the muscles atrophied. Roentgenograms showed enlargement and irregularity of the femoral head with spotty areas of vacuolization and sclerosis; the upper surface was flattened and the articular surface irregular. This was considered an aseptic necrosis with secondary osteoarthritis. An arthroplasty was done, permitting study and biopsy of the joint structures. The ligamentum teres and capsule were grossly normal and microscopically showed normal vascularization. The femoral head showed microscopic changes typical of aseptic necrosis. The author's explanation is that the force producing the dislocation tore the capsule and its blood vessels, depriving the femoral head of a large source of its blood supply. As a result there ensued an aseptic necrosis with collapse of the bony structure, arising from too early weight bearing. LEWIS G. JACOBS, M.D.

Spontaneous Fracture of the Calcaneus. Victor Raisman. Am. J. Surg. **65:** 290–292, August 1944.

A case of spontaneous fracture of the calcaneus in a middle-aged woman with syphilis is reported. Lateral roentgenograms of the foot and ankle five days after the onset of symptoms showed a fracture of the apophysis with an upward displacement of the proximal two-thirds. Under conservative treatment, the pain, swelling, and tenderness disappeared and x-ray studies three months after the occurrence of the fracture showed firm union of the displaced apophyseal fragment.

GYNECOLOGY AND OBSTETRICS

Determination of the Placental Site in Bleeding During the Last Trimester of Pregnancy. James J. McCort, Charles N. Davidson, and Henry J. Walton. Am. J. Roentgenol. **52:** 128–135, August 1944.

The literature on the subject of the roentgen diagnosis of placenta praevia and placental visualization is reviewed. The present report is based on the results of roentgenographic examination in 132 cases. Routinely, an antero-posterior and a lateral roentgenogram of the abdomen were taken, with soft-tissue technic, as recommended by Snow and Powell (Am. J. Roentgenol. **31:** 37, 1934). If the placenta could not be clearly demonstrated in the upper uterine segment, it was considered to be a placenta praevia. In doubtful cases pneumocystograms were obtained after injecting 200 to 250 c.c. of air into the bladder, antero-posterior and lateral views again being taken.

In those cases negative for low implantation or placenta praevia, the vesicocephalic measurement averaged 1.2 cm. In the positive cases the average measurement was 2.0 cm. A sign of additional importance was displacement of the bladder to one side. This occurred when the placenta was implanted on the lateral uterine wall and extended into the lower uterine segment. When the placenta lies posteriorly, the pneumocystograms may be normal. In these cases a widening of the distance between the sacral promontory and the fetal head should be present. Similarly in anterior implantations a widening of the symphysis pubis-fetal head distance should be present. For the entire group of 132 patients, a correct diagnosis was made in 87.8 per cent; of the negative diagnoses, 97 per cent were correct. L. W. PAUL, M.D.

Relationship of Descensus Uteri to Pelvic Size and Morphology and to Certain Obstetric and Economic Factors. A. L. Dippel. Minnesota Med. **27:** 627–631, August 1944.

In an attempt to assign some role to pelvic size and morphology in uterine prolapse, a series of 25 cases was investigated by stereoscopic roentgen pelvimetry and by clinical measurement of the pelvis before operation. The average age of the patients at the time of the prolapse was 42.8 years, with extremes of 21 and 63 years. The majority of the women fell within normal limits as to stature and weight. None of the pelves studied was classified as contracted. Fourteen were gynecoid, 10 platypelloid, and 1 android.

Roentgen findings other than pelvic form included moderate rachitic changes in the sacrum in 9 cases. Four pelves showed high assimilation. One was slightly asymmetrical. There were no instances of spina bifida. In 6 cases, however, the hiatus sacralis involved the lower two or three sacral vertebrae. The significance of this minor developmental anomaly in the lower end of the vertebral column is not clear, but it would seem possible that it might be associated with other anomalies in the development of the neural canal which might conceivably, like spina bifida, be responsible for the production of pelvic relaxation on a neurogenic basis.

As to the obstetric history and economic status of the patients, the author comes to certain conclusions:

"The following factors do not seem to play an important role in the production of descensus uteri: age at onset of symptoms, age at time of first term delivery, age at menopause, parity before onset of symptoms, number of operative vaginal deliveries, and presence of open sacral canal.

"Parity with associated birth trauma is almost always an accompaniment of descensus or prolapse.

"Descensus uteri is much more common in low income groups." Early resumption of hard physical labor following delivery may here be the dominant factor.

PERCY J. DELANO, M.D.

THE GENITO-URINARY TRACT

Supernumerary Ureter with Extravesical Orifice. Wm. W. Scott. J. Urol. **52:** 126–132, August 1944.

In ureteral duplication the insertion of the ureter draining the superior pole of the kidney is always caudad and mediad to that of the ureter draining the lower portion of the kidney. Thus, if there are duplicate ureters one of which has an extravesical orifice, that ureter will always drain the superior pole of the kidney.

Although ureteral duplication is of equal incidence in the sexes, the patients seen are chiefly females. In the male, the extravesical orifice is in the prostatic urethra, seminal vesicle, vas deferens, or ejaculatory duct, where it will not produce incontinence. In the female, on the other hand, incontinence is the cardinal symptom. The author states that a break-through between the wolffian and müllerian ducts will explain the anomaly.

The extravesical orifice may be extremely hard to find. In cases of long-standing infection of the supernumerary ureter, the function of that portion of the kidney drained by this ureter may be so low that there will not be enough clearance of the drugs used in intravenous urography for radiographic detection, or enough clearance of dyes to detect their color in searching for the orifice. With a history of incontinence with normal micturition, the finding of a superior segment of kidney with no apparent drainage system is strongly suggestive of the diagnosis.

The author recommends heminephrectomy as the treatment of choice. In one of his 4 reported cases the orifice was never found; in 2 it was in the urethra, and in the other in the vicinity of Skene's gland. Heminephrectomy produced cure in all cases.

J. FRANCIS MAHONEY, M.D.

THE BLOOD VESSELS

Use of Radioactive Sodium in Studies of Circulation in Patients with Peripheral Vascular Disease: A Preliminary Report. Beverly C. Smith and Edith H. Quimby. Surg., Gynec. & Obst. **79:** 142–147, August 1944.

Having recognized the need of a practical procedure for determining the arterial flow through the main and collateral circulations of the extremities, the authors devised a method whereby radioactive sodium is injected intravenously at the antecubital fossa and its arrival in other parts of the body is recorded with a Geiger-Müller counter. Thus the circulation time can be determined and the rate at which the radioactive isotope comes to equilibrium with extravascular sodium can be studied by repeated counting following the injection. Studies were made on a group of 60 persons, of whom 10 were normal and 50 diseased. The information obtained was a valuable adjunct in determining the patency of the main and collateral circulations. Preoperative studies were confirmed by amputation in some of the cases. No local or systemic reactions were noted.

The method of preparation of the radioactive sodium is summarized. In 5 c.c. of normal saline containing 200 microcuries of radiosodium, fewer than 1 in 10 million sodium atoms are active. However, the ordinary and radioactive ones are indistinguishable until the latter disintegrate. An extremely small amount of magnesium is formed as a result of the disintegration.

A detailed description of the technic is given. The circulation times determined were of clinical value, but the curve of equilibrium build-up is more promising. There is a constant interchange of sodium between the blood plasma and extravascular fluid. Consequently, the amount of radioactive isotope gradually increases in any particular region until equilibrium is reached. In scleroderma, Raynaud's disease, and arteriosclerosis not complicated by diabetes, the equilibrium count curves remained consistently low. Some thromboangiitis obliterans patients with good collateral circulation had normal curves. In 2 cases of "immersion foot" and one of frostbite low curves were also obtained.

Since the amount of radiation received by the patient's body is less than 1 r, it is believed this method will be of aid in the follow-up and evaluation of therapeutic procedures. C. R. PERRYMAN, M.D.

MISCELLANEOUS

Abdominal Tumors of Questionable Origin: Roentgenological Aspects. Adolph Hartung. Illinois M. J. **86:** 14–16, July 1944.

Roentgen examinations aid greatly not only in arriving at a correct diagnosis, but also in determining prognosis or therapy in practically all masses in the abdomen of questionable origin. Close co-operation of the clinician and roentgenologist, based on preliminary fluoroscopy or scout films and a knowledge of the existing symptoms, signs, and laboratory findings, will aid in selecting the specific examination, such as contrast studies of the gastro-intestinal tract, pyelography, cholecystography, hepatolienography, pneumoperitoneography and perirenal air injection, necessary for differential diagnosis. ELLWOOD W. GODFREY, M.D.

Processing X-Ray Films Under Tropical Conditions. A. Porter S. Sweet. U. S. Nav. M. Bull. **43:** 160–161, July 1944.

Excessively high temperatures in film processing solutions will not only destroy most detail of radiographs by fogging, but may so soften the emulsion that it will wash off the base. Sodium sulfate added to the developer makes it possible to use it safely at temperatures up to 110° F. The amount to add will vary with the temperature: 200 gm. per gallon at 80° F.; 300 gm. at 90° F.; 600 gm. at 100° F.; and 800 gm. at 110° F. As the temperature rises, the developing time is reduced: 3 to 4 minutes at 80°; 3 minutes at 90°; 2 minutes at 100°; and one minute at 110° F.

In mixing fixer for use at temperatures above 78° F., only one-half the usual amount of water should be used. The films should be transferred directly from the developer to the fixer with no rinsing in water. This will carry over an extraordinary amount of developer on the film and in the emulsion. Agitation in the fixer helps diffuse the excess developer. It will be necessary to replace the fixer more frequently than normally.

BERNARD S. KALAYJIAN, M.D.

RADIOTHERAPY

Roentgen Therapy with the Army X-Ray Field Unit. Ernest Wayne Egbert. Mil. Surgeon **95:** 30–33, July 1944.

The results in 391 cases treated with the Army x-ray field unit are reported. These cases are classified as surgical (chiefly infections) and dermatological. In no case was any deleterious effect observed. Two hundred and forty cases or 61.38 per cent were followed through and the end-results recorded on completion of roentgen therapy or within six weeks thereafter. Of these 240 cases, 90.4 per cent were clinically cured or improved. Only 23 cases were observed with "no benefit" following use of roentgen irradiation. One hundred and eighteen of the 192 dermatological cases (89 per cent) were benefited; 91.8 per cent of the surgical cases were cured or improved.

Roentgen therapy with the army mobile unit is performed in a properly lead-walled room, and a mobile leaded screen gives added protection to the operator. All therapeutic procedures are performed at 100 kv.p. and 4 ma. A special stop-watch, attached on the operator's side of the protective screen, is used to time all treatments. Lead diaphragm inserts in the "useful beam" of radiation limit the field of treatment, and supplementary protection is used in draping the treatment field with lead rubber sections. Dosage calibration for the unit has been checked by the Victoreen apparatus and "r" values have been found within ±10 per cent of those given by the manual accompanying the unit.

NEOPLASMS

Operability Versus Curability of Cancer of the Breast. U. V. Portmann. Ohio State M. J. **40:** 742–745, August 1944.

The variations in interpretation of the terms "operable" and "inoperable" by equally competent surgeons reporting results of radical mastectomies for carcinoma are cited by the author as probably explaining much of the difference in end-results shown. If the objective is the removal of as much malignant tissue as possible, regardless of the stage of advancement of the disease, the five-year survivals will represent a small part of the total, and many patients will be made worse rather than be improved. If, on the contrary, the objective is to operate only on those patients whose extent of disease warrants the belief that it can be totally removed, the five-year survivals will represent a much larger part of the total. The author believes that if the terms "surgically curable" and "surgically incurable" were used instead of the worlds "operable" and "inoperable," objectives for treatment would be more clearly defined and more agreement would be reached about the manifestations of incurable cancer.

Much of the uncertainty about the value of irradiation for breast carcinoma is due to lack of proper classification of cases in reporting results. Often advanced cases of the disease treated by irradiation are compared with others far less advanced treated by operation. If survival rates alone serve as standards, such compari-

sons are misleading. In the author's statistical comparison of results in cases treated by operation alone and those by operation plus irradiation, it was found that the classification of cases by clinical and pathological criteria had not been satisfactorily carried out. The anatomical extent of involvement should govern the indications for and the limitations of treatment and the prognosis. A classification based on clinical and pathological criteria was developed referring only to primary cases of carcinoma. It is as follows:

Group I. *Skin:* not involved. *Tumor:* localized in breast and movable. *Metastases:* none in axillary nodes or elsewhere.

Group II. *Skin:* not involved. *Tumor:* localized in breast and movable. *Metastases:* few axillary lymph nodes involved, none elsewhere.

Group III. *Skin:* edematous; brawny red induration or inflammation not obviously due to infection; extensive ulceration; multiple secondary nodules. *Tumor:* diffusely infiltrating the breast; fixation of tumor or breast to chest wall; edema of breast; secondary tumors. *Metastases:* many axillary lymph nodes involved or fixed; no clinical or roentgenological evidences of remote metastases.

Group IV. *Skin:* as in any other group or stage. *Tumor:* as in any other group or stage. *Metastases:* axillary and supraclavicular lymph nodes extensively involved; clinical or roentgenological evidence of more remote metastases.

The author illustrates the applicability of this classification in the study of 1,022 cases of breast cancer, of which 738 were classifiable. The table showing classification by this method is very interesting and should be studied in the original article. Almost half (47.2 per cent) of all primary cases were found to be in Groups III and IV when first examined.

The highest survival rates for surgery alone are obtained in Groups I and II. If postoperative irradiation is of benefit in prolonging life, it should be evident in the results obtained in Groups III and IV. In these groups, there were 5.8 per cent five-year survivals with operation alone, while among those receiving postoperative irradiation the five-year rate was 13.4 per cent. Those receiving irradiation alone have as good a yearly survival rate as those treated solely by operation.

No patients in Group III and IV can be said to be "cured." Careful analysis of the clinical and pathological criteria of these patients shows that most are incurable when first examined. Criteria for determining incurability of cancer of the breast are as follows:

Skin:

1. Edema (orange or pig skin) of more than slight extent.
2. Ulceration of more than slight extent.
3. Brawny red and inflamed, not obviously due to infection.
4. Multiple secondary nodules.

Breast:

1. Diffusely edematous.
2. Diffusely infiltrated.
3. Multiple secondary tumors.
4. Fixation to the chest wall.

Metastases:

1. Axillary lymph nodes numerous, extensively involved and fixed.
2. Supraclavicular lymph nodes or edema of arm.
3. Involvement of contralateral breast or lymph nodes.
4. Remote metastases in bones, lungs, or other viscera.

Some patients with these manifestations might be considered "operable," but all are "surgically incurable." There is little to justify subjecting these incurable cases to radical operation. They should be treated by irradiation alone, as just as many or more survive, their economic usefulness is prolonged, and they receive palliation. BERNARD S. KALAYJIAN, M.D.

Carcinoma of the Larynx. Review of Treatment and End Results at the Brooklyn Cancer Institute. W. E. Howes and M. Platau. Arch. Otolaryng. **40:** 133–138, August 1944.

Of 68 men and 3 women with lesions proved to be carcinoma of the larynx who were admitted to the Brooklyn Cancer Institute from 1934 through 1942, 17 were still living at the time of this report. Of the surviving patients, 13 had intrinsic laryngeal carcinoma and 4 extrinsic carcinoma. The average age for the whole group was 58 1/2 years.

When the carcinoma is localized, operation offers the greatest opportunity for cure, and it is therefore the policy at the Institute to excise the growth when possible. Lesions too advanced for excision are usually referred for radiation therapy.

Palliative Procedures: Tracheotomy and gastrostomy are performed only for relief of symptoms and cannot therefore be considered as in any sense curative. Thirty-six patients underwent tracheotomy and 2 gastrostomy. Many of the tracheotomized patients were later treated with roentgen radiation.

Surgical Treatment: Four types of surgical treatment were carried through in this series: (*a*) electrocoagulation, (*b*) epiglottic resection, (*c*) laryngofissure, and (*d*) laryngectomy. Surgical procedures are performed on selected patients, which should give this group a certain advantage as to end-results.

Three patients received *electrocoagulation* directed to an extralaryngeal growth. Recurrence followed fulguration in each instance; subsequent roentgen therapy resulted in the survival of 1 in 3.

One patient, with the tumor arising in the extrinsic larynx, was treated by *epiglottic resection* and was living and well, without evidence of disease, at the time of this report.

Laryngofissure was performed on 9 patients with intrinsic cancer. One died of complications seven years after operation. Five were living at the time of the report; one of these received radiation therapy for recurrence.

Laryngectomy was performed on 5 patients. In each the cancer arose in the intrinsic larynx. Two patients were living without evidence of disease. Two patients received radiation in addition—1 radium, 1 roentgen rays. Neither of these survived.

Curative Radiotherapy: Both radium and roentgen rays have been used in the treatment of laryngeal carcinoma. Teleradium therapy requires large quantities of radium and at best is difficult because of the bulk and weight of the radium container. Radium can be applied interstitially in the form of needles or gold implants. Such insertion produces trauma to the part, however, and the evenness of the distribution of the sources of radiant energy is largely dependent on the

individual skill of the operator and the location and extent of the growth. Up to the present, none of the radium procedures appears to have any advantage over treatment with high-voltage roentgen rays, which the authors regard as the more efficient modality for irradiation. All patients treated in the Brooklyn Cancer Institute have received roentgen radiation, by a modified Coutard technic with repeated daily doses, calculated in the manner described by Howes and Bernstein (Am. J. Roentgenol. **50:** 76–88, 1943).

Fifty-four patients in this series were given roentgen therapy, 43 of this number receiving a so-called therapeutic dose, *i.e.*, 4,875 r or more to the tumor in one continuous cycle of not over seven weeks' duration. The remaining 11 patients received various doses up to 4,875 r. Of the 43 patients given a therapeutic dose, 24 are listed as having a neoplasm that arose in the extrinsic larynx and 19 one that arose in the intrinsic larynx. Ten, or 23.25 per cent, of the 43 patients are living to date (February 1944).

Only carcinoma arising on the vocal cords (intrinsic) was observed to be amenable to surgical treatment in this series. Radiation therapy was shown to be of value both in carcinoma arising on the cords and carcinoma of the extrinsic structures of the larynx.

Extramedullary Plasma Cell Tumor of the Mouth. James R. Stancil and Wray J. Tomlinson. Arch. Otolaryng. **40:** 139–141, August 1944.

An extramedullary plasma-cell tumor (plasmocytoma) of the mouth destroyed the uvula and part of the palate and involved the tonsils and tonsillar pillars in a 26-year-old Salvadorian mestizo. The lesion was grossly destructive and showed lateral extension but no anaplasia on microscopic examination. It was not suitable for excision, and roentgen therapy was instituted. Clinical extension ceased and local regression occurred, with healing. Treatment was divided into two series, with an interval of about a month. It consisted of a daily dose of 100 to 150 r in air given through two lateral cervical portals, each 10 × 10 cm. The factors were: 200 kilovolts (peak); 20 ma.; 50 cm. target-skin distance; 0.5 mm. copper and 1.0 mm. aluminum filtration. The total dose administered was 3,000 r in air to each portal. There had been no extension or recurrence of the growth in the nine-month period following the last treatment.

Report of Case of Retroperitoneal Hemangioendothelioma. T. J. Snodgrass. Surgery **15:** 988–993, June 1944.

The case here reported is of interest because a diagnosis of sarcoma was made, but in the final examination the tumor proved to be of a much lower degree of malignancy.

The patient was a white female, aged 51 years, who was admitted because of fever, nervousness and fatigue, pain under the ribs on the left side, tenderness in the right lower quadrant, and pus cells in the urine. A tender mass was palpable halfway between the iliac crest and the lower ribs on the right. Immediately following hospitalization the leukocyte count varied from 14,000 to 19,000, the temperature ranged from 99.8 to 101.8° F., and the mass decreased in size daily. Five days later, however, it suddenly became larger and the leukocyte count increased. Exploration was undertaken and a huge retroperitoneal tumor was found extending down below the anterior iliac spine, over the umbilicus, and up to the liver on the right. The tumor appeared hemorrhagic. A diagnosis of myxosarcoma or sympatheticoblastoma was made. The wound was packed and later closed. Frequent blood transfusions were required.

A retrograde pyelogram showed displacement of the kidney and ureter toward the mid-line, and a large indefinite mass was shown on a scout film. Following x-ray therapy (6,000 r) and administration of Coley's toxins, the patient's condition improved, with decrease in the size of the mass, an increase in hemoglobin, and a drop in the leukocyte count. X-ray examination a month later showed the tumor to be well encapsulated and of irregular density. It was outlined on intravenous urography, and a barium enema study showed displacement of the right hepatic flexure downward. It now appeared that surgical removal was possible. At operation the tumor was found to reach from below the crest of the ilium up almost to the costal margin and to be retroperitoneal. It appeared to be derived from the outer aspect of the right kidney. The postoperative diagnosis was probable hypernephroma.

Microscopic examination of the tumor showed it to be composed of numerous somewhat thick-walled blood vessels of arteriolar size, surrounded by cuboidal and cylindrical cells which appeared to arise from the vessel wall. Other vessels were of capillary size and still others were large and thick, containing areas of hyalinization and myxomatous changes. Neoplastic cells radiated from both the small and large vessels. The final diagnosis was retroperitoneal hemangio-endothelioma.

The patient left the hospital about six weeks later, and after another month was given a second series of x-ray treatments (3,600 r). Fourteen months after removal of the tumor, she was in good health and without evidence of recurrence.

The fever and leukocytosis observed in this case during the period of activity were probably the result of degenerative changes in the growth itself. With hemorrhage into the tumor there was a rapid drop of hemoglobin out of proportion to the blood loss. Response to radiation and Coley's toxins was sufficient to cause a regression of the tumor and, with it, a drop in the leukocyte count and an increase in the hemoglobin, but this response was not sufficient to give any assurance that complete regression would take place without excision. J. E. WHITELEATHER, M.D.

Lymphoblastoma in Children Under Thirteen Years of Age. Ira I. Kaplan. J. Pediat. **25:** 155–160, August 1944.

Neoplasms in children are usually of the highly cellular type and therefore a preponderance of lymphomatous conditions is observed. Of the 27 children thirteen years and under with lymphoblastoma, referred to the Radiation Service of the Bellevue Hospital, 10 had leukemia, 11 Hodgkin's disease, and 6 lymphosarcoma. Although many Negro children are admitted to Bellevue Hospital, 25 patients in this series were white; there was 1 Negro and 1 Puerto Rican.

In 7 patients, the leukemia was of the lymphatic type; in 3, myelogenous. There were 6 boys and 4 girls in this group. The age of the youngest child was thirteen months and of the oldest six years. The blood count was indicative of the condition in all patients; the highest white cell count was 88,000. X-ray ther-

apy produced temporary relief in all patients. The longest known period of survival was four months after treatment.

The 11 patients with Hodgkin's disease were older than those with leukemia, the oldest being thirteen and the youngest eighteen months. Hypertrophied lymph nodes were the most common symptom. Roentgen examination showed chest involvement in 3 patients. Diagnosis in all cases was confirmed by biopsy. Treatment was by high-voltage x-rays, either to the involved node areas and/or to the chest; in some cases, to the spleen. Of the 11 patients, 7 are known to be dead.

All of the 6 patients with lymphosarcoma were under six years of age. Four were boys. Three had chest symptoms, 3 swellings of the neck. Biopsy proved the diagnosis in 5 cases. In one patient, death occurred during treatment. Even following autopsy, it was not decided in this case whether the correct diagnosis was leukemia or lymphosarcoma transformed into leukemia. In this group, 3 are known to be dead.

Although the results with radiotherapy in lymphoblastomatous conditions have not been favorable, no other method of treatment offers any more optimistic outlook. More gradual over-all irradiation, with greater attention to supportive therapy, may prove more successful. The toxemia following irradiation in small children is a serious sequel, not to be overlooked.

Relationship Between the Lymphoblastic Tumor and the Digestive Tract. J. Borak. Am. J. Digest. Dis. **11:** 241–244, August 1944.

Lymphoblastic tumors are of two main varieties, lymphogranuloma (Hodgkin's disease) and lymphosarcoma. Both develop in the lymphatic tissue and may spread throughout the entire lymphatic system. The lymph nodes of some regions, as the neck and mediastinum, are invariably affected, while those along the digestive tract are less often involved.

The author has seen 8 cases in which enlarged lymph nodes along the digestive tract caused pressure symptoms. Five of the cases are described in this article. In all temporary relief from symptoms was afforded by deep therapy. JOSEPH T. DANZER, M.D.

NON-NEOPLASTIC CONDITIONS

Radiation Therapy as a Method of Treatment in Non-Malignant Conditions. Louis M. Piatt. Ohio State M. J. **40:** 738–741, August 1944.

Some of the reasons for lack of wide acceptance of radiation therapy as a useful modality in the treatment of non-malignant diseases are the multiplicity of theories on the action of radiation in inflammation, the need for further understanding of the biological reactions, the inability of the patient to perceive any immediate beneficial effect, and the relatively high cost of these treatments. The author states Desjardins' theory that the clinical improvement following irradiation of inflammatory conditions is not due to direct bactericidal action but to production in the tissues of antibacterial endotoxins which destroy bacteria and aid healing (Radiology **29:** 436, 1937). He also quotes Pendergrass and Hodes (Am. J. Roentgenol. **45:** 74, 1941) as stating that in acute inflammation the response is due more to vascular changes induced than to destruction of leukocytes. No sharp dividing line between acute and chronic inflammation is available, though in the latter fibrin deposit is less prominent and there is more lymphocytic infiltration and giant-cell formation. The unusual susceptibility of lymphocytes to radiation and the knowledge that it is these cells which are chiefly concerned in antitoxic activity explain much of the beneficial effect of radiotherapy in chronic inflammatory conditions. These changes cannot be duplicated in the test tube, and animal experimentation along these lines is not directly applicable to the treatment of human ills.

In bursitis, there is often an initial aggravation of symptoms after roentgen therapy, but beneficial effects follow in many cases and calcium deposits frequently disappear. Relief from pain is complete in 60 to 70 per cent and partial in 10 per cent; about 20 per cent receive no benefit. The author recommends 100 to 250 r at one- to three-day intervals.

In arthritis, before anatomic changes occur in bone and cartilage, marked relief of pain is frequently obtained—60 to 70 per cent of patients are greatly and 20 to 30 per cent slightly improved. Permanent bony deformities are not influenced. The author believes that radiation is particularly useful in Marie Strümpell spondylitis. Moderately filtered radiation in moderate dosage is recommended.

In the treatment of pneumonia, sulfonamides are of great value, but roentgen therapy may be used in those who do not tolerate the sulfa drugs or do not respond to them, in the aged, and in those with serious heart, liver and kidney disease. It should not be used simultaneously with chemotherapy. In virus pneumonia, the effect of roentgen therapy is often dramatic. One or two treatments of 50 to 100 r daily or every other day are recommended.

Several authorities are quoted as to the effectiveness of roentgen therapy in asthmatic conditions. Signal relief has been obtained in a high percentage of patients, and often better results in the more severe and protracted cases. The author recommends irradiation at 200 kv.p., with moderate filtration, through four to six portals.

In the treatment of sinus disease and other otolaryngological conditions, small doses are considered more effective in acute cases. Subacute cases respond best but need higher dosage. Results in children are excellent. Roentgen treatment of otitis media is also recommended. In cases with hypertrophy of lymphoid tissue about the eustachian tube, the alleviation of deafness is often excellent. The author urges discretion in the use of this modality in all these conditions and warns that it is not a panacea.

Hemorrhage at the climacteric without fibroids or cancer is frequently relieved by proper application of roentgen or radium therapy. Reduction in mortality and morbidity make these preferable to surgery in many cases. Radium therapy is easier to apply, requires less treatment time, produces less radiation sickness, and stops hemorrhage more quickly. However, roentgen treatment of the ovaries may also be needed Many fibroids are reduced in size or disappear completely, but the larger ones should be handled surgically. Menopausal symptoms are less frequent than following surgical castration but more common than after hysterectomy without castration.

Many other lesions of non-malignant character are briefly mentioned as being benefited by radiation therapy. BERNARD S. KALAYJIAN, M.D.

X-Ray Treatment of Sinusitis. Frederick T. Munson and Henry T. Munson. Am. J. Surg. **65:** 95–97, July 1944.

In the authors' experience, small doses of roentgen radiation have been found to relieve pain in a high percentage of patients with acute sinus conditions, in some instances within four to six hours after the first treatment. Cases of acute sinusitis accompanied by pain and tenderness responded much more readily and dramatically than the chronic types of sinus inflammation. The following factors were used: 150 kv.p., 15 ma., 50 cm. skin-target distance, and a filter of 0.25 mm. Cu + 1 mm. Al. Treatments were given at intervals of two to six days, but usually at three-day intervals. The amount of radiation given at each treatment was either 100 or 150 r. Of the last 20 patients receiving x-ray therapy for acute sinus disease, 11 experienced immediate relief after one treatment, 4 after three treatments, while in 3 patients five or six treatments were necessary.

Plasma Cell Mastitis. Report of Five Additional Cases. Willard H. Parsons, John C. Henthorne, and R. Lee Clark, Jr. Arch. Surg. **49:** 86–89, August 1944.

Though uncommon, plasma-cell mastitis is important because of its clinical resemblance to carcinoma of the breast. The characteristic feature is a painless unilateral tumor in a parous woman. Mild and evanescent signs of inflammation are present in the course of its development, and there may be a creamy discharge from the nipple. The lesion is not tender, and is often adherent to the skin so as to produce "orange-peel" dimpling. The nipple is frequently retracted, and the axillary lymph nodes may be enlarged. The gross lesion is a yellowish-brown discoloration of the mammary tissue, often with abscess formation. The contents of the abcess and adjacent ducts are puriform or buttery. Histologically there is ulceration of the duct epithelium with replacement by granulation tissue, formation of foreign-body giant cells, and periductal collection of plasma cells and other leukocytes. The clinical resemblance to carcinoma is so close as to lead to radical operation in most cases. The condition is thought to be due to inflammatory reaction to the lipid ductal contents.

In the discussion following this paper, Dr. R. L. Sanders suggests that, in view of the close histologic resemblance to comedo carcinoma, the lesion may well be precancerous. LEWIS G. JACOBS, M.D.

Diabetes Insipidus. Clinical Observations in Forty-two Cases. George M. Jones. Arch. Int. Med. **74:** 81–93, August 1944.

In 34 of 42 cases of diabetes insipidus seen at the University Hospital (University of Michigan), the etiologic factors were clinically or pathologically determined. On the basis of this study, it is pointed out that diabetes insipidus is a symptom complex produced by injury to the supraopticohypophyseal tract, and not a specific entity. In any case of diabetes insipidus thorough and repeated examinations should be made to determine the etiologic factors. Urine concentration tests indicate that patients with diabetes insipidus receiving a limited fluid intake continue to secrete urine of low specific gravity, with resultant loss of body weight. In any case in which such a response is obtained, the diagnosis of organic damage along the supraopticohypophyseal tract should be made.

Ideally, therapy in any case of diabetes insipidus should be directed toward the etiologic factor. Thus, in the presence of a neoplasm of the hypothalamus and pituitary or of Hand-Schüller-Christian disease, a good response to roentgen irradiation may be obtained, while antisyphilitic therapy corrects those cases resulting from syphilis. As diabetes insipidus is not infrequently the first symptom of a neoplasm, having occurred eight months and six years before other evidence of the malignant growth in 2 of the author's cases, a trial of roentgen irradiation of the hypothalamicohypophyseal region may well be worth while when the cause of the diabetes is undetermined. Of 4 of the author's cases in which roentgen irradiation of the pituitary and hypothalamus was carried out because of neoplasm involving these regions, relief of the symptoms of diabetes insipidus was obtained in 3. The neoplasm in one case was apparently not radiosensitive. In 3 cases of Hand-Schüller-Christian disease (xanthomatosis) in which roentgen therapy was applied to the region of the pituitary, a good response was obtained in one case and a moderate response in another.

Of the various methods of administration of posterior pituitary substance as replacement therapy in the absence of the antidiuretic principle, intramuscular injection of pitressin tannate in oil seems the most desirable. Use of a low salt diet as an adjunct to other therapy may be worth a trial in any case of diabetes insipidus. Thyroidectomy should not be performed for diabetes insipidus unless there are other specific indications for the procedure.

Radiotherapy of Ectopic Calcification. E. Millington. Brit. M. J. **2:** 148–149, July 29, 1944.

The author opens this short but pertinent article by expressing regret that the English surgeons fail to recognize the value of radiotherapy as completely as do the Americans.

The histology of ectopic calcifications is described and the rule offered that absorption can be caused by radiation only up to the time of new bone formation. The treatment recommended in subdeltoid bursitis consists of 200 r per week for four weeks, at 200 kv. with 0.5 mm. copper filter. The symptoms are relieved in six weeks, and changes are then apparent in the shadows on the x-ray film. Q. B. CORAY, M.D.

EFFECTS OF IRRADIATION

A Note on Irradiation Sickness. William B. Bean, Tom D. Spies, and Richard W. Vilter. Am. J. M. Sc. **208:** 46–54, July 1944.

Nausea, vomiting, headache, cramps, and diarrhea comprise the syndrome of irradiation sickness often complicating the course of therapeutic irradiation. From previous successful attempts at treatment of this illness with nicotinic acid, and with the discovery that the behavior of urinary pigments and the cohydrogenases I and II following irradiation over the spleen resembled that in severely ill pellagrins, it was planned to make a comprehensive examination of the effects of a standard dose of radiation. Normal well-fed subjects, those given a vitamin-deficient diet with and without some of the vitamins, pellagrins, and those whose poor diet had resulted in illness without specific deficiency stigmata were investigated.

The irradiation factors were: 200 kv., a Thoraeus

filter, 20 ma., 20 cm. distance, 33 r per minute. The dose was 400 r over the upper abdomen and spleen.

Five normal subjects consuming a good diet or various vitamin B supplements showed no ill effects. Irradiation sickness occurred in varying degrees of severity in the rest of those studied, including the normal subjects who had subsisted on a vitamin B-deficient diet for six weeks. In all cases there was a rough correlation between the severity of the reaction and the degree of vitamin depletion as gauged clinically.

Once the illness was established, large doses of thiamine or nicotinic acid were of relatively little value. Irradiation sickness could be prevented or reduced in severity if the vitamin supplements were given for a few days before therapy was started.

A patient with myomata and carcinoma of the uterus suffered from severe irradiation sickness because of repeated doses of irradiation. She was not given supplements of vitamins, and subsequently pellagra and beriberi developed.

It would appear from these studies that the optimum time for vitamin therapy is before and not after irradiation sickness develops. The fact that patients needing radiotherapy often have a deranged nutrition makes careful dietary and vitamin therapy logical, if only on empiric grounds. BENJAMIN COPLEMAN, M.D.

Effect of Roentgen Rays on the Minute Vessels of the Skin in Man. Eugene P. Pendergrass, Philip J. Hodes, and J. Q. Griffith. Am. J. Roentgenol. **52:** 123–127, August 1944.

The effect of roentgen rays on the minute vessels of the skin was studied by means of the capillary microscope. Areas of skin on the extensor surface of the forearm were selected, the opposite forearm being used as a control. Capillary counts were made before, six hours after, and twenty-four hours after irradiation. A final count was made after pricking the skin through a drop of 1:1,000 histamine to determine the total capillaries in the area under observation. The patients, 84 in number, were divided into four groups and the results were as follows:

In Group I (333 r in air delivered in 3/4 minute at 200 kv. (peak), 15 cm. target-skin distance) a significant dilating effect on the skin capillaries was observed after six hours and was largely gone after twenty-four hours.

In Group II (301 r in air delivered in 7.2 minutes at 200 kv. (peak), 50 cm. target-skin distance) a distinct dilating effect was observed six hours after exposure and was still present, but to a lesser degree, at the end of twenty-four hours.

In Group III (308 r delivered in 30.8 minutes at 200 kv. (peak), 50 cm. target-skin distance) there was no significant change seen in the skin capillaries after six hours and no very definite effect in twenty-four hours.

In Group IV (300 r delivered in 1 minute at 50 kv. (peak), 3 cm. target-skin distance) a moderate capillary effect was observed at the end of six hours, becoming more marked after twenty-four hours.

The responses of the subpapillary venous plexus to irradiation were also recorded. In Group III, which showed the least effect on the capillaries, there was the greatest effect upon the subpapillary venous plexus, but the reason for this was not clear.

The differences in the responses of the capillaries and venous plexuses seem related to the method of irradiation. L. W. PAUL, M.D.

Rectal and Colonic Complications of Pelvic Irradiation. Herbert I. Kallet and M. Jordan Thorstad. Surgery **15:** 980–987, June 1944.

Following irradiation of the cervix or other pelvic organs, complications involving the rectum and lower colon may occur. These sequelae present serious and often perplexing diagnostic and therapeutic problems. Radiation therapy for carcinoma of pelvic organs is, however, an accepted procedure, and the serious nature of the original disease justifies the risk of subsequent complications. Before irradiation is recommended for benign conditions which are amenable to surgery, the question of secondary damage to the intestine must be carefully considered.

Injury to the connective tissue and blood vessels first exhibits itself in the form of edema. With further trauma, an endarteritic process develops, with thickening of the walls and gradual decrease in size of the lumen. Damage to the endothelial lining induces thrombosis and occlusion with infarct formation. The infarcted tissue is replaced by fibroblastic scar, which gradually undergoes sclerosis and hyalinization. Both striated and smooth muscle cells are also destroyed by heavy irradiation and are replaced by connective tissue.

The rectal and intestinal mucous membranes are very sensitive to the action of these destructive rays. Because of its anatomic proximity to the uterus, the lower intestine is within sharp radiation focus when the cervix is treated.

The complicated sclerosing process tends to progress as months go by. Hardening and shrinkage of the posterior pelvic and parametrial tissues take place. A firm mass may thus be formed below the uterocervical junction, which extends backward to the second and third sacral vertebrae. Ensnared in this fixed mass may be the vagina, the ureters, and the rectum. The vagina becomes stenosed and deformed, obstruction of the ureters may occur, and frequently stenosis of the rectum or sigmoid develops.

For convenience the sequelae may be grouped as follows:

1. Radiation proctosigmoiditis.
2. Entrapment.
3. Extension.
4. Fistula formation.

These may occur singly or in combination.

The most common intestinal complication following irradiation is *proctosigmoiditis*. This may vary in intensity from simple irritation to deep eschar formation. Symptoms may set in shortly after radium insertion, reaching maximum severity six or eight weeks later. There is diarrhea with increased mucus, the stools assuming a frothy character. Abdominal cramps and tenesmus are present, and the act of defecation gives incomplete relief. Scant amounts of blood may be found in the stool, but gross hemorrhage is uncommon. On digital exploration the sphincters will usually be found spastic. The proctoscopic picture varies with the degree of injury. Early, the mucosa appears edematous and much mucus will be seen. The membrane is hyperemic and easily traumatized. Later, with more severe involvement, patches of eschar will be visualized, yellow-white plaques sometimes an inch or more in diameter.

The condition is usually temporary. Treatment involves rest, both physical and mental; an adequate but non-irritating diet, and sedatives. The injection of

one of the oil-soluble anesthetics will relax sphincter spasm. Irrigations and colonic flushes may do more harm than good. Cod-liver oil, instilled once or twice daily, is soothing and seems to hasten resolution. Bismuth, kaolin and other drugs forming a protective bowel coating may at times be indicated. In favorable cases the reaction gradually subsides.

A serious sequel to irradiation is a stenosis of the sigmoid or upper rectum as the bowel is compressed by the firm fibrotic mass of the frozen pelvis. This *entrapment* takes place slowly over a period of months or even years, with the development of an intestinal obstruction of increasing severity. The stenosis is ordinarily palpable by digital examination. Occasionally it is only visualized by sigmoidoscopy or demonstrated by x-ray study.

The symptoms are those of increasing constipation; bowel movements may be preceded or accompanied by lower abdominal pain. The constipation is at length supplanted by a diarrhea of a paradoxical type, the patient having frequent small, unsatisfactory movements. The lack of appetite, anemia, loss of weight, vague pains, and abdominal distress in a patient known to have had a carcinoma are easily misinterpreted as an indication of metastasis. An early recognition of the benign nature of the stenosis changes the prognosis to a more favorable one.

Treatment depends upon the degree of stricture and the general condition of the patient. If the passage, though narrowed, is adequate, a low-residue diet and the regular administration of mineral oil may prove successful. When the obstruction is more severe, laparotomy must be done. Often colostomy must be performed.

Whenever rectal symptoms develop, the question at once arises; has extension or metastasis of the growth taken place? It is quite possible for the initial lesion in the cervix or elsewhere to resolve completely after irradiation and yet for invasion of the bowel wall to be present. The neoplasm may advance through the rectovaginal septum or extend laterally along the peritoneum of the posterior abdominal wall. In the latter instance, pain is generally a principal symptom. It is severe, neuralgic in character, radiating down the left sciatic distribution. The pain in septal invasion is less intense.

Digital examination and sigmoidoscopy will usually differentiate a recurrence from the pseudocarcinoma brought about by inflammation and fibrosis. In recurrence the mass is more localized, it is raised and often polypoid, unlike the smoother stenosis of entrapment. Biopsy is, of course, the most accurate means of differentiation.

When recurring carcinoma is found, the radiologist must consider whether or not further irradiation is advisable. Here the possibility of factitial ulceration and the development of rectovaginal fistula becomes great. It is well in these recurrences to recommend colostomy early, both to avoid pain and to lessen the chance of fistula formation.

The development of *rectovaginal fistula* is a most distressing sequela. It may result from infarction brought about by destructive action of the radiation or as a result of secondary infection. The fistulas vary in size from pin-point openings to large defects. In small fistulas, relief may be secured by inducing constipation, the dry, formed stool being unable to leak through the perforation. Most patients with rectovaginal fistulas will require colostomy.

The author gives case reports illustrating each type of complication. J. E. WHITELEATHER, M.D.

Radioactivity and Lung Cancer; A Critical Review of Lung Cancer in Miners of Schneeberg and Joachimsthal. Egon Lorenz. J. Nat. Cancer Inst. **5:** 1–13, August 1944.

The author reviews the studies of lung cancer in the miners of Schneeberg and Joachimsthal (see, for example, Pirchan and Šikl: Am. J. Cancer **16:** 681, 1932; Saupe: Fortschr. a. d. Geb. d. Röntgenstrahlen **60:** 163, 1939) in the light of the experimental work of such investigators as Read and Mottram (Brit. J. Radiol. **12:** 54, 1939) on the production or attempted production of lung tumors in mice. He concludes that the opinion that radon is the sole cause of lung cancer in these miners is not supported by the evidence at hand. A comprehensive bibliography is included.